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The Distribution and Ecology of the Aquatic Gastropoda of Marquette County, Michigan

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THE DISTRIBUTION AND ECOLOGY OF THE AQUATIC GASTROPODA OF MARQUETTE COUNTY, MICHIGAN

by

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A Thesis

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ABSTRACT

An attempt was made in this study to correlate some environmental factors with the abundance and distribution of aquatic snails in Marquette County, Michigan. The survey was conducted during the summer of 1974.

Twenty-nine species of aquatic snails were taken from one hundred and forty-nine waters in Marquette County. All of these snails had been previously reported from Michigan. A brief comparison was made between the snail fauna of Dickinson, Menominee, Schoolcraft and other counties of the Upper Peninsula. *Viviparus georgianus*, *Somatogyrus subglobosus*, *Lymnaea columella*, *Lymnaea exilis*, *Gyraulus circumstriatus*, and *Helisoma truncatum* were found in Marquette County waters and are the first known records from the Upper Peninsula. The majority of species collected during this study have been found in Minnesota, Wisconsin, Illinois, Indiana, and Ohio. *Amnicola limosa* was the most abundant snail found during this study, while *Helisoma anceps* was the most frequently encountered.

Aquatic snails were not commonly found in acidic waters. The pH of water probably has an effect upon the distribution and abundance of aquatic snails indirectly by affecting the food organisms that are able to survive in such waters. The temperature, depth, color and bottom composition of the waters investigated in this study were determined and related to the numbers and distribution of some freshwater snails.

ACKNOWLEDGEMENTS

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INTRODUCTION

Since no comprehensive study of the ecology of aquatic snails has been performed in Marquette County, Michigan, the present study was undertaken to determine what aquatic snails are present in selected areas of the county and to describe their abundance and distribution. The species of aquatic snails were also compared with those of Dickinson, Menominee, Schoolcraft and other counties of Michigan's Upper Peninsula, from which species lists have been published.

Some biological and physical features of the habitats studied were also considered in an attempt to determine the most important factors regulating the abundance and distribution of aquatic snails. Distribution data were compared to distribution records from other parts of the state of Michigan and also to midwestern states.

LITERATURE REVIEW

In 1837, when Michigan was admitted to the Union, one of the first acts of the first legislature was the establishment of the State Geological Survey, headed by Dr. Douglass Houghton as geologist and Dr. Abram Sager as zoologist (Walker, 1906). After two years of collecting and identifying, Dr. Sager published the first faunistic list which included vertebrates and invertebrates of Michigan. Although seventy-six species of minute snails were included in his list, little taxonomic work was performed at this time(Walker, 1906). A period of twenty years or more elapsed before serious attention was again given to furthering knowledge of the Michigan fauna. Alfred Currier published in 1859 a list of shells collected from Grand River Valley, Michigan (Goodrich, 1943). In 1861 a catalogue of the mammals, birds, reptiles and mollusks of Michigan was published by Manly Miles(Walker, 1906). In 1863 Theodore Gill described the family Amnicolidae, basing his conclusions on the shape of the animal, the foot, tentacles, branchiae, and genitalia(Berry, 1943). William Stimpson published his "Researches Upon the Hydrobiinae" in 1865, thereby contributing greatly to the study of the Amnicolidae of North America(Berry, 1943). W. G. Binney in 1865 published Part III of the "Land and Freshwater Shells of North America"(Berry, 1943). In this work, Binney substantiated much of Stimpson's research.

Several faunal lists were published by various authors between 1865 and 1890: by Currier in 1865, (Catalogue of the Mollusca of Grand Rapids, Michigan) and 1868 (List of the Shell-bearing Mollusca of Michigan); by Bryant Walker and Charles E. Beecher in 1876 (List of Land & Freshwater Shells Found Within a Circuit of Four Miles about Ann Arbor, Michigan), by Walker in 1879 (Catalogue of the Shell-bearing Mollusca of Michigan), and by DeCamp in 1881 (List of Shell-bearing Mollusca of Michigan)

(Walker, 1906). In spite of the contributions of Stimpson and Binney, many of the specimens collected by DeCamp, Currier, Walker and Beecher were often mis-identified(Berry, 1943). From 1895 to 1912, many contributors, mostly in the form of short faunal lists of certain regions of Michigan, were published by various authors. A. G. Ruthven (1904) published a paper entitled "Notes on the Mollusks, Reptiles, and Amphibians of Ontonagon County, Michigan."H. B. Baker in 1909 published a "Key to the Genera of Gastropoda of Michigan" and Bryant Walker published a report on the Mollusca collected in the vicinity of Charlevoix, Michigan in the summer of 1894 and also made a checklist of the Mollusks of Michigan in 1911(Berry, 1943). Walker's checklist of Michigan Mollusca was a great advance over all previous lists. Revision in taxonomy by several conchologists changed the nomenclature used by Walker in his checklist of 1911. A revised check list of Michigan Mollusca published by Mina L. Winslow (1926) included the more recent changes in taxonomy, however, it was still based primarily upon Dr. Walker's list of 1911. In 1911 the total number of species and varieties of mollusks on the list was 398. In the 1926 revised check list, the total had been increased to 428. Records proven false and never authenticated were removed from the list and many names were added. Of the mollusks enumerated, 107 were freshwater pulmonates, and 35 were freshwater operculas, bringing the number of aquatic snails to about 142. Mina L. Winslow(1917) published an annotated list of mollusk shells collected from Alger, Chippewa, and Schoolcraft counties of

Michigan's Upper Peninsula. This list included 28 species of freshwater snails taken from these counties. Frank Baker(1928) reported on the aquatic molluscan fauna of the State of Wisconsin. His report included descriptions of the shells and animals, their distribution, ecology and economic importance. A list of mollusk shells from Alcona, Oscoda and Crawford counties of Lower Michigan was compiled from several sources by Winslow(1921). H. Burrington Baker (1922) published a paper on mollusks from Dickinson County in Michigan's Upper Peninsula. The paper included many descriptive notes on the habitats visited.

In the spring of 1931, in the course of ornithological studies upon Keweenaw Point, Keweenaw County, Michigan, Norman A. Wood collected a number of mollusks. In the material collected, nine freshwater species and subspecies were cited, along with eight terrestrial species and subspecies(Goodrich, 1931). Dr. John N. Lowe, a former Professor of Biology at Northern Michigan University, in the summer of 1927, devoted much of his time to collecting mollusks from a number of streams and lakes of Menominee County in the Upper Peninsula of Michigan. He recorded many habitat descriptions and distributional data. His collection was later sent to the Museum of Zoology, University of Michigan, shortly before his death in 1938. Goodrich's(1932) handbook on the Mollusca of Michigan covers taxonomy, distribution, and habitat descriptions. Goodrich and Van der Schalie's(1939) paper on aquatic mollusks of the Upper Peninsula of Michigan was primarily a compilation of all the data from previous works performed by Baker, Lowe, and Marsh. Allan Archer(1939) along with the cooperative efforts of a number of researchers studied the ecology of the molluscan fauna of the Edwin S. George Reserve in Livingston County, Michigan. A paper was published on the Amnicolidae of Michigan by Elmer G. Berry(1943) and dealt only with those species known to occur in Michigan. The work was carried on for four years and during this time information dealing with the characters and comparative structure of the shells and comparative morphology of the animals, as well as data on distribution and ecology, was gathered. Very few taxonomic keys have been published on freshwater gastropods in Michigan. Elmer G. Berry's publication on the Amnicolidae of Michigan(1943), and The Key to the Genera of Freshwater Gastropods(Snails and Limpets)Occurring in Michigan(Walter and Burch, 1957) are the only published keys of the aquatic snails of Michigan.

METHODS AND MATERIALS

Limnological Techniques

Chemical Methods: The only chemical characteristic of the water that was measured in this study was pH. Due to the large number of collecting sites visited during this study, the pH of the water was not measured by means of a pH meter, but rather by pH paper. The pH was determined at the time collections were made. The precision of the pH paper used was later determined to be ± 0.1. This value was obtained by comparing the pH paper's range of values to several pH solutions measured with a Corning Model 12 Research pH meter.

Physical Methods: Several physical features were noted at the time of collection. The physical characteristics described are those which existed at the exact location where snails were collected.

1. Bottom Composition : The bottom descriptions are based on the following bottom classification system of Roelofs(Welch, 1952, page 26):

   I Homogeneous: having uniform composition.

   A. Inorganic.

   1. Bedrock or solid rock.
   2. Boulders: rocks more than 12 in. in diameter.

3. Rubble: rocks 3-12 in. in diameter.

4. Gravel: 1/8 - 3 in. in diameter.

5. Sand: may be divided into coarse and fine.

6. Clay: very finely divided mineral material; no gritty feeling; usually gray in color.

7. Marl: calcium carbonate; usually gray in color.

B. Organic.

1. Detritus: coarse plant material, fragmented but little decayed.

2. Fibrous peat: partially decayed plant remains; parts of plants recognizable.

3. Pulpy peat: very finely divided plant remains; particles unrecognizable; green to brown; consistency variable, often semifluid.

4. Muck: black; finely divided organic matter; decomposition very advanced.

2. <u>Depth</u>: The depth was measured by means of a yard stick, although at a few sites where the water was deep estimations were made.

3. <u>Color</u>: The water color descriptions were based on gross observations. No color analyses were performed.

4. Temperature: The water temperature was measured by means of a Centigrade thermometer.
5. Lentic vs Lotic: Aquatic snails were collected from standing and running waters and the frequency of species inhabiting both types was compared.

Biological Data: At each collecting site, the dominant floral and faunal inhabitants associated with the aquatic snails were noted and recorded.

Collecting Methods

The aquatic snails referred to in this study were collected in the following ways:

1. Examination of submerged rocks, logs, sticks, boards, and any other submerged objects in the body of water.
2. Use of a dip net to capture snails clinging to submerged aquatic plants or adhering to the surface film.
3. Scooping up debris from the bottom, such as organic sediment and submerged leaves. This material was examined for aquatic snails by picking through it with forceps.
4. Examination of floating aquatic plants such as water lilies (*Nuphar advena* and *Nymphaea odorata*) for snails attached to the plant.

Preservation of specimens:

The aquatic snails collected were taken to the laboratory in the living state. A label denoting the date and location of the collection site was inserted into each jar containing snails. The snails were rinsed thoroughly in water to remove any mud from the shell, and then were preserved in a solution of 70% ethyl alcohol.

Identification:

The identity of the snails was determined by using one of the several keys listed in the Literature Cited. The characteristics of the shell were used to determine the identity of the snails. In a few cases identification to the species level was determined by the use of descriptive material rather than using a taxonomic key. Immature specimens which could not be identified to species were identified to genus.

After the snails were identified, the members of one species from a single collection were placed into a jar containing 70% ethyl alcohol. A label designating the collector's name, date of collection, locality, locus, county, state, catalogue number, and the genus and species name, was inserted into each jar.

A taxonomic classification of aquatic gastropods is given in Appendix Table A1, page 104. A listing of the station numbers, dates on which the collecting was done, and the species and number of each found is shown in Appendix Table A5, pages 141-162.

Cataloguing:

The following catalog system was used for the preserved snails:

The first Arabic number or series of Arabic numbers in the code is the collecting site identification number, i.e., each collecting site was assigned a specific identification number. The second series of Arabic numbers represent the month in which the collection was made, the third series the day, and the fourth set of Arabic numbers designates the year. Following the four series of Arabic numbers are Roman numerals used to designate the family to which a certain species belonged, capital letters the genus, and small letters the species. For example, the code 1-6-3-74VHa would mean that the collection was made at Harlow Creek (designated by the 1-) during the month of June(-6-), the third day(-3-) in the year 1974(-74). V would represent the family Planorbidae, H the genus *Gyraulus*, and a the species *parvus*.

Catalog Code to Aquatic Snail Collection

First series of Arabic numbers= Identification number for the collection site.

Second series of Arabic numbers= Month in which collection was made.

Third series of Arabic numbers= Day in which collection was made.

Fourth series of Arabic numbers=Year in which collection was made.

Roman Numerals=Family

I	Valvatidae	V	Planorbidae
II	Amnicolidae	VI	Lymnaeidae
III	Viviparidae	VII	Physidae
IV	Ancylidae		

Capital Letters=Genera

A	*Valvata*	G	*Helisoma*
B	*Amnicola*	H	*Gyraulus*
C	*Somatogyrus*	I	*Promenetus*
D	*Viviparus*	J	*Lymnaea*
E	*Campeloma*	K	*Physa*
F	*Ferrissia*	L	*Aplexa*

Small Letters=Species

Genera		Species	Genera		Species
Valvata	a	*tricarinata*	*Somatogyrus*	a	*subglobosus*
	b	*sincera*	*Viviparus*	a	*georgianus*
Amnicola	a	*limosa*	*Campeloma*	a	*decisum*
	b	*lustrica*	*Ferrissia*	a	*parallela*
	c	*integra*		b	*tarda*

Small letters = Species (cont'd.)

Genera		Species	Genera		Species
Helisoma	a	trivolvis	Menetus	a	exacuous
	b	campanulatum	Lymnaea	a	obrussa
	c	anceps		b	columella
	d	truncatum		c	megasoma
Gyraulus	a	parvus		d	exilis
	b	deflectus	Physa	a	gyrina
	c	hirsutus		b	ancillaria
	d	umbilicatellus		c	integra
	e	altissimus	Aplexa	a	hyponorum
	f	circumstriatus			

The Study Area

Introduction

One-hundred and forty-nine sites including lakes, ponds, bogs, swamps, rivers, and creeks were sampled throughout Marquette County.

The names used to designate collecting stations were those used on maps supplied by the Michigan Department of Natural Resources. Where no known name could be found for a particular body of water, a name was derived for it based upon some distinct characteristic of the collecting site.

Figure 1 shows the location of Marquette County. Figure 2, pages 15-20, depicts the locations of the waters studied in Marquette County. Appendix Tables A2, pages 105-115, and A3, pages 116-130, denote the dominant floral and faunal inhabitants of the waters studied. Table A4, pages 131-140 shows the physical features of the waters investigated during this study.

Habitat Descriptions (Marquette County):

Appendix Tables A2, A3 and A4 on pages 105-140, depict several physical and biological characteristics of the waters investigated. Because of the large number of sites visited during this study, a habitat description for each site was not given. Instead, a brief description of the various types of habitats visited throughout the study is given, and at the end of each description is listed by number the collecting stations which would fit that particular type of habitat.

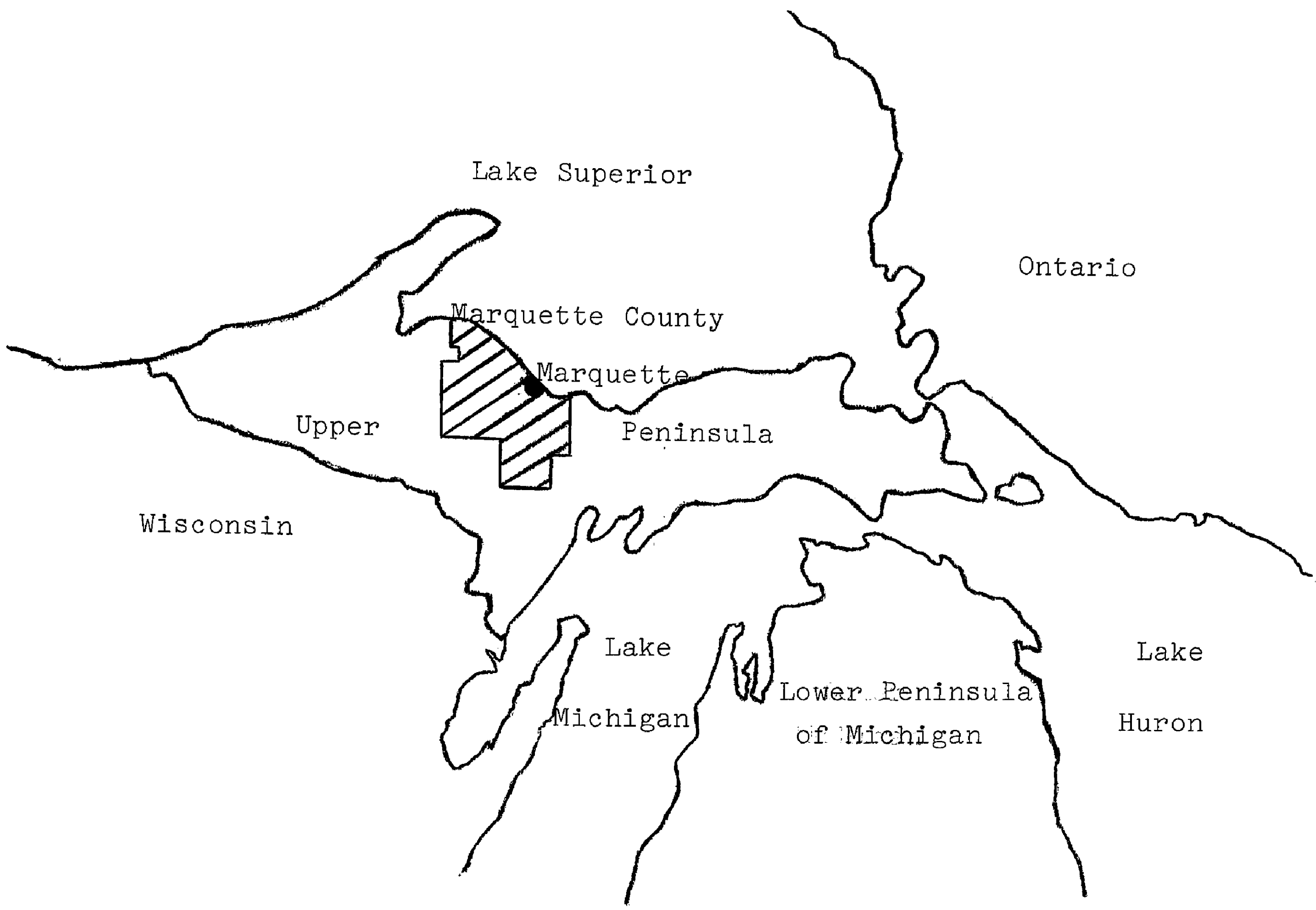


Fig. 1. Upper Peninsula of Michigan showing the location of Marquette County.

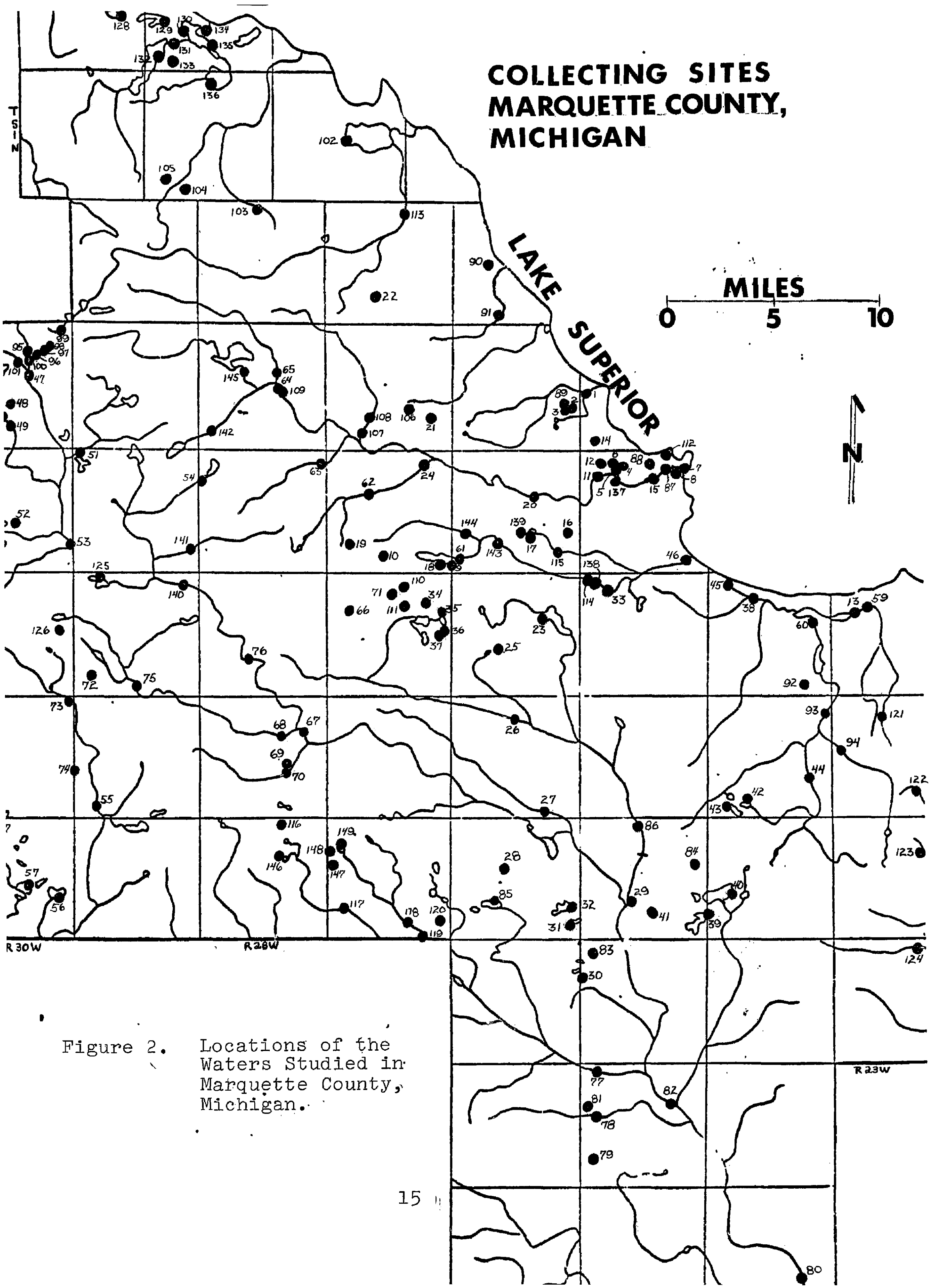


Figure 2. Locations of the Waters Studied in Marquette County, Michigan.

Fig. 2(cont'd). Locations of the Waters Studied in Marquette County, Michigan.

1. Harlow Creek
2. North Harlow Lake
   (Site 1, T49NR26WS24)
3. Harlow Lake
   (T49NR25WS19)
4. Redberry Minor
   (Site 1, T48NR25WS8)
5. Redberry Minor
   (Site 2, T48NR25WS8)
6. Redberry Major
7. Dead River
   (Across from U.P. Generating Co. Steam Plant, T48NR25WS11)
8. Dead River
   (200 ft. west of Site 7, T48NR25WS11)
9. Teal Lake
   (T48NR26WS31)
10. Deer Lake
    (south half)
11. Dead River
    (Forestville area, T48NR25WS10)
12. Waldo Pond
13. Mud Creek
14. Wetmore Pond
15. Dead River
    (T48NR25WS10)
16. Bagdad Pond
17. Horseshoe Lake
    (T48NR26WS27)
18. Teal Lake
    (T48NR27WS36)
19. North Deer Lake
20. Dead River
    (T48NR26WS15)
21. 510 Road Swamp
    (T49NR27WS25)
22. 510 Road Ditch
    (T50NR27WS28)
23. Goose Lake
24. Little Dead River
    (T48NR27WS11)
25. Warner Creek
26. Schweitzer Creek
27. Green Creek
28. Horseshoe Lake
    (T45NR26WS15)
29. East Branch of Escanaba River (T45NR25WS21)
30. Anderson Lake
31. Little Shag Lake
32. Big Shag Lake

Fig. 2 (cont'd). Locations of the Waters Studied in Marquette County, Michigan.

33. Carp River (T47NR25WS5)

34. Cedar Lake

35. Miller Lake

36. Ogden Lake (T47NR27WS13)

37. Ogden Lake (T47NR27WS14)

38. Chocolay River (T47NR24WS8)

39. Bass Lake

40. Little Lake

41. Johnson Lake

42. Engman's Lake

43. Sporley Lake

44. East Branch of the Chocolay River

45. Chocolay River (T47NR24WS6)

46. Carp River (T48NR25WS36)

47. Peshekee River (Site 1, T49NR30WS15)

48. Arfelin Lake

49. Little White Goat Creek

50. Section 28 Lake

51. Dishno Creek

52. Lake 42

53. Lake Michigamme

54. Kippie Creek

55. Michigamme River (T46NR29WS31)

56. Witch Lake

57. Horseshoe Lake (T45NR30WS22)

58. Squaw Lake

59. Lake LeVasseur

60. Chocolay River (T47NR24WS24)

61. Teal Lake Drainage Creek (T48NR26WS31)

62. Little Dead River (T48NR27WS17)

63. Barnhardt Creek

64. Dead River (T49NR28WS22)

Fig. 2 (cont'd). Locations of the Waters Studied in Marquette County, Michigan.

65. Mulligan Creek
66. Carp River (T47NR27WS17)
67. Middle Branch Escanaba River (T46NR28WS11)
68. Black River Falls
69. Rocky Creek
70. West Branch Creek
71. Bancroft Lake
72. Bruce Creek
73. Michigamme River (T46NR30WS1)
74. Trout Falls Creek
75. Black River
76. Middle Branch of Escanaba River (T47NR28WS28)
77. Big West Branch of the Escanaba River
78. Little West Branch of the Escababa River
79. Lone Pine Creek
80. Boney Falls Basin
81. Chymes Creek
82. Escanaba River
83. Bilsky Lake
84. Swanzy Lake
85. Pike Lake
86. East Branch of the Escanaba River (T45NR25WS4)
87. Dead River (T48NR25WS11)
88. Bullhead Lake
89. North Harlow Lake (Site 2, T49NR26WS24)
90. Saux Head Lake
91. Garlic River
92. Foster Creek
93. Chocolay River (T46NR24WS1)
94. West Branch Nelson Creek
95. Lower Baraga Lake
96. Gateway Pond

Fig. 2 (cont'd). Locations of the Waters Studied in Marquette County, Michigan.

97. Gateway Creek

98. Two-Gate Pond

99. White Deer Lake

100. Baraga Creek

101. Peshekee River (Site 2, T49NR30WS15)

102. Lake Independence

103. East Tributary of East Branch Salmon Trout River

104. East Tributary of West Branch Salmon Trout River

105. West Tributary of West Branch Salmon Trout River

106. Stickleback Pond

107. Deer Creek

108. Clark Creek

109. Dead River (T49NR28WS22)

110. Lake Bacon

111. Lake Angeline

112. Compeau Creek

113. Bear Lake

114. Carp River (T47NR25WS6)

115. Morgan Creek

116. Little Perch Lake

117. Camp 11 Creek

118. Bryan Creek

119. Kates Lake

120. Charley Lakes

121. East Branch LeVasseur Creek

122. West Branch Whitefish River

123. McMaster's Creek

124. Werner Creek

125. Fish Lake

126. Twin Lake

127. Chief Lake Drainage Creek (T45NR30WS5)

128. Howe Lake

129. Rush Lake

130. Pine Lake

Fig. 2 (cont'd). Locations of the Waters Studied in Marquette County, Michigan

131. Mountain Stream
132. Mountain Lake
133. Trout Lake
134. Pine River
135. Middle Pine Lake
136. Ives Lake
137. Dead River (T48NR25WS8)
138. Carp River (T47NR25WS5)
139. Horseshoe Pond
140. Middle Branch of Escanaba River (T47NR29WS1)
141. Second River
142. Connors Creek
143. Carp River (T48NR26WS29)
144. Carp River (T48NR26WS30)
145. Dead River (T49NR28WS17)
146. Dewey Lake
147. Trout Lake
148. Drake Lake
149. Spear Lake

The criteria used to distinguish between lakes, ponds, bogs, swamps, rivers and creeks are denoted.

Lakes

> "Many lakes may be described as bodies of standing water having an area of open relatively deep water sufficiently large to produce somewhere on its periphery a barren, wave swept shore."(Welch, 1952, page 16).

The lakes visited during this study were of various sizes, occupying an area as large as 1,860 acres (Lake Independence) to much smaller lakes occupying less than 50 acres. As a partial indication of lake diversity, it might be stated that lakes are deep or shallow; protected or unprotected; with or without tributaries and outlets; acid, neutral, or alkaline; turbid or clear; high or low in dissolved content, and with marl, muck , sand, or false bottoms(Welch, 1952). These many characters occur in many combinations and thus account for the diversity that exists among lakes. A few typical floral inhabitants of the lakes visited during this study include pondweeds(Potamogeton spp.), water lilies (Nuphar advena and Nymphaea odorata), bur reed(Sparganium spp.), sedge(Carex spp.), bulrush(Scirpus spp.), arrowhead(Sagittaria spp.), rushes(Juncus spp.), stonewort(Chara sp. and Nitella sp.), eelgrass(Vallisneria sp.), waterweed(Anacharis sp.), and watermilfoil(Myriophyllum sp.). Some faunal inhabitants encountered in the lakes studied include crayfish(Orconectes sp.), clams, leeches, oligochaeta, aquatic insect naiads, diatoms, copepods, isopods(Asellus sp.), sponges(Spongillidae), and aquatic nematodes. Many species of fish such as bullheads(*Ictalurus nebulosus*), northern pike(*Esox lucius*), yellow perch (*Perca flavescens*), along with sunfishes (*Lepomis spp.*), and salmonids were frequently found in the lakes visited during the study. The following numbers correspond with the collecting stations that are lakes: 2, 3, 9, 10, 17, 18, 19, 23, 28, 30, 31, 32, 34, 35, 36, 37, 39, 40, 41, 42, 43, 48, 50, 52, 53, 56, 57, 58, 59, 71, 80, 83, 84, 85, 88, 89, 90, 95, 99, 102, 110, 111, 113, 116, 119, 120, 125, 126, 128, 129, 130, 132, 133, 135, 136, 146, 147, 148, and 149.

Ponds

> Ponds are bodies of standing water less than 15 feet deep, occupying an area less than five acres and having quiet water in which there is extensive occupancy by higher aquatic plants.

The diversity that exists among lakes is also represented in ponds. Owing to the small areas involved, water movements in ponds are usually minimal. Even in the most exposed ponds, wave action is very slight, while other forms of water movement, such as currents are present in appreciable form only in those ponds which are expanded portions of stream systems. Because of the shallow depth and the large expanse of surface as compared with volume, pond waters in general tend to follow the temperatures of the atmosphere(Welch, 1952). Turbidity in ponds varies greatly with such features as the productivity, inflowing sediment, and also the nature of the basin. While some ponds may be clear, others are very muddy. There does exist, however, all possible integrades between these extremes. The shallow depth of most ponds usually makes it possible for light to penetrate to the bottom enabling an abundant variety of plant life to occupy much of the pond. Typical floral inhabitants found in the ponds visited during this study include water lilies(Nuphar advena and Nymphaea odorata), bullrush(Scirpus spp.), cattails(Typha sp.), pondweeds(Potamogeton spp.), bladderwort(Utricularia spp.), spike rush(Eleocharis sp.), horsetails(Equisetum sp.), waterweed(Anacharis sp.), and stonewort(Chara sp.). Of the invertebrates, protozoa, rotifers, aquatic insect naiads, crustaceans, and leeches were commonly encountered in the ponds. Among the vertebrates, amphibians especially frogs appear to constitute the important faunal group encountered at ponds, where fishes are few in number or absent except in the larger permanent ponds. The following collecting stations visited in this study are ponds: 4, 5, 6, 12, 16, 96, 98, 106, and 139.

Bogs

> "While bogs are of different types, depending upon such features as vegetational composition of the bog margin, origin and nature of the false bottom, and stage in ecological succession, most of them have certain general features in common of which the following are prominent: (1) absence, or poor development of a bottom fauna, (2) a marginal flora peculiar to such situations, (3) partial decomposition of plant remains to form peat, (4) definite qualitative zonation of the vegetation forming the marginal mats; and (5) generally low biological productivity."(Welch, 1952, page 392).

Since the only bog in which aquatic snails were collected in this study was relatively small and is protected by surrounding hills and rocks, water movements due to wind action are probably minimal. In bogs that are small where there is little water movement, the water usually tends to be clear, the slight turbidity being due to plankton and also to a small amount of finely divided peaty matter which is essentially nonsettling (Welch, 1952). The bog visited during this study was associated with Wetmore Pond and can be characterized by having a sphagnum mat, sundews(*Drosera sp.*), bog cranberries(*Vaccinium macrocarpon*), pitcher plants (*Sarracenia purpurea*), and leatherleaf (*Chamaedaphne calyculata*). Faunal inhabitants included leeches, freshwater sponges, and aquatic dragonfly naiads. The usual acidic waters of most bogs generally eliminate all mollusks, with the possible exception of certain clams(Sphaeridae) which may be abundant. Representatives of the Amphibia, such as frogs, appeared to be usually present as marginal forms. Typical bog fish encountered in the bog was the mudminnow(*Umbra limi*) and a few northern redbelly dace(*Chrosomus eos*).

Rivers

Bodies of running water whose width exceeds fifteen feet along most of its course.

Several rivers were visited during this study, including the Dead River, Carp River and the Chocolay River. The Dead

River transverses most of Marquette County from West to East and empties into Lake Superior. The river varies in depth, water movement, turbidity, and bottom composition along its course. Some of the floral inhabitants of the Dear River include pondweeds(<u>Potamogeton</u> <u>spp</u>.), water milfoil (<u>Myriophyllum</u> <u>sp.</u>), waterweed(<u>Anacharis</u> <u>sp</u>.), stonewort(<u>Chara</u> <u>sp.</u>), and a variety of grasses(Gramineae). Invertebrates include aquatic mayfly and dragonfly naiads, sponges(Spongillidae) clams(Sphaeridae and Unionidae), crayfish(<u>Orconectes</u> <u>sp.</u>), and amphipods. Many fish are found in the Dead River, including salmonids and cyprinids.

The Carp River is also an extensive body of water which flows throughout Marquette County. It possesses many tributaries and empties into Lake Superior. The river has a bottom that varies considerably in composition, consisting of sand in some areas, and of mud with detritus in other areas. Aquatic plants frequently found in the Carp River include pondweeds(<u>Potamogeton</u> <u>spp.</u>), waterweed(<u>Anacharis</u> <u>sp.</u>), stonewort(<u>Nitella</u> <u>sp</u>.), and grasses (Gramineae). Invertebrates found in this river include amphipods, crayfish(<u>Orconectes</u> <u>sp.</u>), aquatic beetles, clams, aquatic dragonfly and mayfly naiads, and caddis larvae(Trichoptera). Salmonids and cyprinids along with some bullheads(<u>Ictalurus</u> <u>sp.</u>), and darters are the most abundant fish present in this river.

The Chocolay River along with its tributaries drains the southeast portion of Marquette County. The bottom is mostly sandy with some detritus, but there are areas where the bottom is mucky. Some of the common aquatic plants of this river include pondweeds(Potamogeton spp.), yellow pond lilies (Nuphar advena), waterweed(Anacharis sp.), and grasses(Gramineae). Invertebrates such as crayfish(Orconectes sp.), clams, leeches, caddis larvae(Trichoptera), water boatmen(Corixidae), aquatic beetles, amphipods(Hyalella sp.), and isopods (Asellus sp.) are abundant. Cyrinids and salmonids are also common in the Chocolay River .

The many other rivers visited throughout this study had bottom characteristics, flora and fauna, similar to those major rivers previously described. The following numbers correspond with the collection stations that are rivers: 7, 8, 11, 15, 20, 24, 29, 33, 38, 44, 45, 46, 47, 55, 60, 62, 64, 66, 67, 68, 73, 75, 76, 77, 78, 82, 86, 87, 91, 93, 101, 103, 104, 105, 109, 114, 122, 131, 134, 137, 138, 140, 141, 143, 144, and 145.

Creeks

Bodies of running water whose width is usually less than fifteen feet along most of its course. The creeks visited throughout this study were of the following two types:

Creek (swift-water type)

"Fast flowing water with hard stable bottom, with no pelagic communities; the fishes and insects present are predominantly bottom dwellers or else are involuntary drift forms from the pools above."(Welch, 1952, page 432).

These creeks had fast moving water with bottoms consisting mainly of sand with gravel, rubble, or boulders and perhaps some detritus. Little vegetation was found in these creeks except fòr grasses(Gramineae), some pondweeds(Potamogeton spp.), bur reed(Sparganium androcladum), and sweet gale(Myrica gale) along the shoreline. Aquatic insects were very numerous in these creeks, particularly caddis larvae(Helicopsyche borealis and Limnephilus sp.), and dragonfly, mayfly and stonefly naiads. Freshwater sponges(Spongillidae), crayfish(Orconectes sp.), clams(Pisidium sp.), and aquatic beetles(Coleoptera) were also found in the swift-water type creeks. Few vertebrates were encountered except for some cyprinids. The following numbers correspond with collecting stations that were considered to be creeks with fast flowing water: 26, 51, 54, 63, 65, 69, 70, 74, 79, 92, 94, 100, 107, 108, 118, 121, 123, and 124.

Creek (sluggish-water type)

> "Slow-moving waters with soft unstable bottoms, decaying organic matter frequently accumulated on the bottom, with rooted vegetation common and pelagic and bottom faunas more abundant and diversified."(Welch, 1952, page 432).

These creeks had bottoms that consisted mainly of muck with some sand, gravel, rubble, and detritus. Grasses(Gramineae), waterweed(Anacharis sp.), bladderwort(Utricularia sp.), and stonewort(Chara sp.) were frequently found in these creeks. Sedges(Carex sp.), horsetail(Equisetum sp.), sweet gale(Myrica gale), and willow (Salix sp.) were generally common along the shoreline. Common faunal inhabitants of these creeks include leeches, crayfish (Orconectes sp.), clams (Sphaeriidae), sponges (Spongillidae), aquatic bugs (Hemiptera), and aquatic dragonfly naiads. Cyprinids and sticklebacks appeared to be the dominant fish present. The only amphibians seen were frogs typically near the shoreline. The following numbers correspond with the collecting stations that are creeks with sluggish water: 13, 25, 27, 49, 61, 72, 81, 97, 112, 115, 117, 127, and 142.

Swamp

> "A pond of such small depth that it is occupied by rooted vegetation whose stalks extend into the air." (Welch, 1952, page 15).

Connors creek (swamp) and 510 Road swamp were visited during this study. These two sites had bottoms that were composed of muck and detritus. Tree stumps were present throughout the areas. The predominant floral inhabitants were grasses (Gramineae), and some water milfoil (Myriophyllum sp.). Invertebrates included crayfish (Orconectes sp.) and many dragonfly naiads (Odonata). The only vertebrates seen were a few cyprinids.

Ditch

> A shallow depression along a road receiving surface runoff and overflow from a nearby creek.

The 510 Road Ditch receives the overflow from Little Pup

Creek. The bottom composition of the ditch was composed of muck with some detritus. A few sticks, stones, and cans were also present. Grasses (Gramineae) were abundant along the sides of the ditch. Invertebrates included clams (Sphaeriidae), crayfish (*Orconectes sp.*), and many dragonfly naiads (Odonata). No vertebrates were seen.

Results and Discussion

Abundance

The number of aquatic snails of each species collected from 149 locations in Marquette County is shown in Appendix Table A5, pages 141-162. Figure 3 indicates the frequency of occurrence.

The total number of each species of snail collected is based on the number of adults that could be identified to species. Immature specimens were not considered in the determination of total numbers. Because there are few published descriptions of quantitative methods for collecting aquatic snails (Hairston, Nelson, et al., 1958), and most of these have dealt with snail vectors of trematode parasites, especially those affecting man, the time spent for collecting was not recorded. Relative abundance, however, may be inferred by comparing the numbers of each species collected.

Table 1, pages 32-33 shows that *Amnicola limosa* was the most abundant aquatic snail found in Marquette County waters, with 656 individuals having been taken. The following species are in order of abundance *Helisoma anceps*, *Physa gyrina*, *Gyraulus parvus*, and *Helisoma trivolvis*.

The least abundant species found during this study were *Gyraulus umbilicatellus*, *Aplexa hyponorum*, *Lymnaea megasoma*, *Somatogyrus subglobosus*, *Gyraulus altissimus*, and *Helisoma truncatum*. *Lymnaea megasoma*, once fairly common throughout the

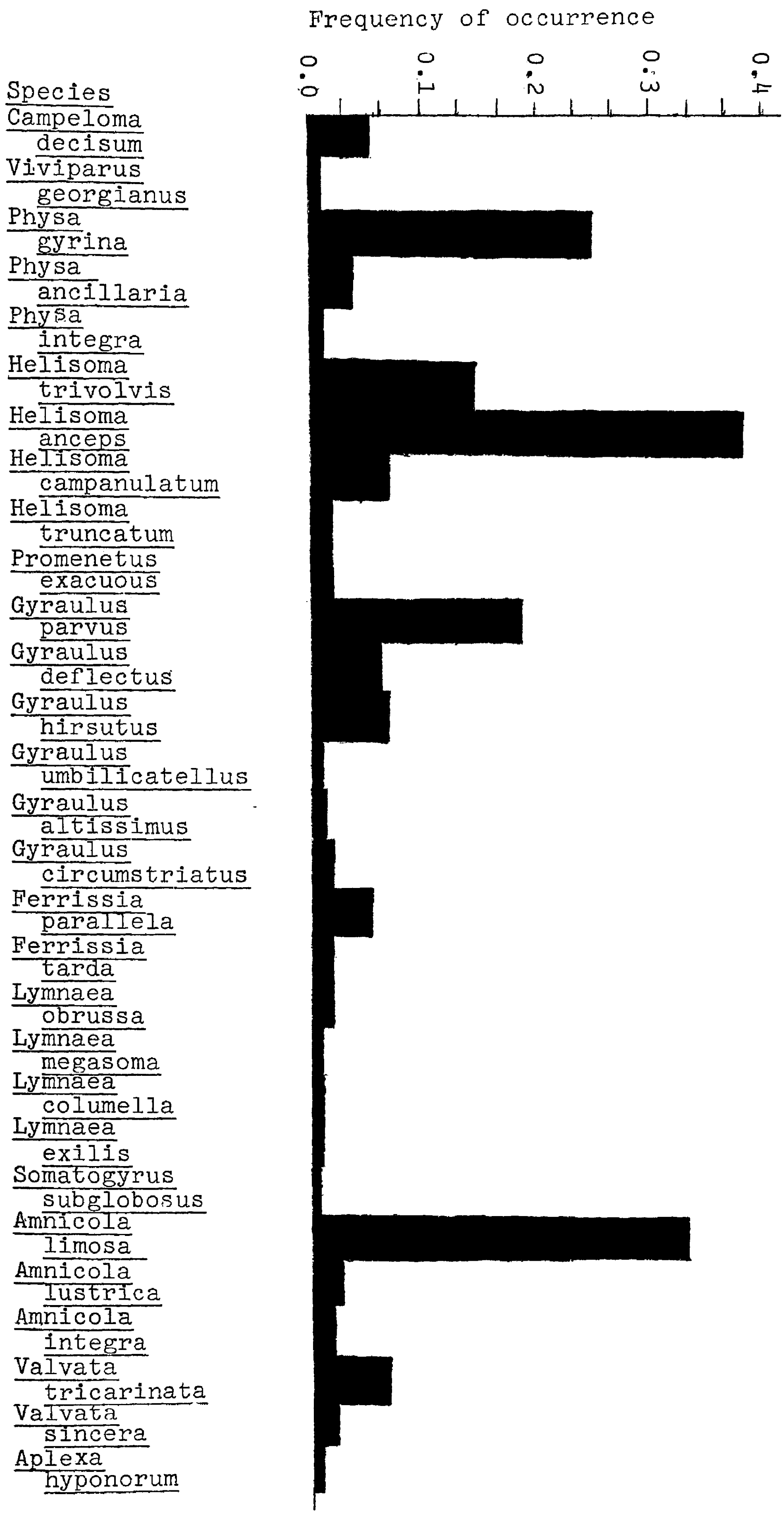


Fig. 3. The Frequency of Occurrence of Snails in one hundred and forty-nine waters in Marquette County.

Table 1. Relative Abundance and Frequency of Occurrence of Aquatic Snails in Marquette County.

Species	Number Collected	Percent of Number Collected	Number of Sites where Species was Collected	Frequency (Percent)
Amnicola limosa	656	33	50	34
Helisoma anceps	378	19	56	38
Physa gyrina	252	13	37	25
Gyraulus parvus	172	8.6	28	19
Helisoma trivolvis	120	5.9	22	15
Gyraulus deflectus	69	3.5	10	6.7
Valvata tricarinata	63	3.2	11	7.4
Helisoma campanulatum	49	2.5	11	7.4
Gyraulus hirsutus	33	1.6	11	7.4
Valvata sincera	26	1.3	4	2.7
Campeloma decisum	24	1.2	8	5.4
Ferrissia parallela	22	1.1	9	6.0
Amnicola lustrica	20	1.0	5	3.4
Physa ancillaria	18	0.89	6	4.0

Table 1. (cont'd.)

Species	Number Collected	Percent of Number Collected	Number of Sites where Species was Collected	Frequency (Percent)
Gyraulus circumstriatus	13	0.65	3	2.0
Lymnaea obrussa	12	0.60	3	2.0
Ferrissia tarda	11	0.55	3	2.0
Lymnaea exilis	11	0.55	2	1.3
Amnicola integra	11	0.55	3	2.0
Viviparus georgianus	9	0.45	1	0.7
Lymnaea columella	5	0.25	2	1.3
Promenetus exacuous	5	0.25	3	2.0
Physa integra	3	0.15	2	1.3
Helisoma truncatum	3	0.15	3	2.0
Gyraulus altissimus	3	0.15	2	1.3
Somatogyrus subglobosus	2	0.10	1	0.67
Lymnaea megasoma	2	0.10	1	0.67
Aplexa hyponorum	1	0.05	1	0.67
Gyraulus umbilicatellus	1	0.05	1	0.67

Upper Peninsula and in northern Lower Michigan, is becoming rare (Goodrich and Van der Schalie, 1939). This species, abundant in the 1920's in marshes bordering Lake Huron in Mackinac County, was absent when the place was revisited in 1936. Summer residents of the area were apparently using the shallows as a dumping ground for waste, thereby eliminating this species from the area. Baker (1928) believes Gyraulus altissimus to be an extinct form peculiar to the Pleistocene period and which is found only in bodies of water having marl deposits on the bottom. Somatogyrus subglobosus is a deep water inhabitant of the Great Lakes and deep rivers and thus probably accounts for its scarcity in inland bodies of water. Gyraulus umbilicatellus, Aplexa hyponorum, and Helisom truncatum were not abundant in the waters sampled, and this may be due to a lack of thorough searching.

Figure 3 shows that Helisoma anceps was encountered more frequently than any other snail in Marquette County waters. It was found in about 38% of the habitats studied. Baker (1928) found Helisoma anceps abundant in rivers and creeks in Wisconsin and Illinois. This species is also common in lakes or in the quiet regions of creeks and rivers in Michigan (Van der Schalie and Berry, 1973).

The following most frequently encountered species are in order, Amnicola limosa, Physa gyrina, Gyraulus parvus, and Helisoma trivolvis. Berry (1943) has stated that Amnicola limosa is usually so common that other amnicolids in smaller numbers have been entirely overlooked at times. The five most abundant species, Amnicola limosa, Helisoma anceps, Physa gyrina, Gyraulus parvus, and Helisoma trivolvis were also the most widespread species, as revealed by their high frequency of occurrence. These species also occur frequently throughout Wisconsin, Illinois, and Indiana(Baker, 1928).

The size of aquatic snails may influence both the total number taken and the frequency with which they were encountered during this study. The amnicolids, freshwater limpets(Ancylidae), and members of the family Valvatidae are small aquatic snails that may be less conspicuous than the larger snails of the families Lymnaeidae, Viviparidae, Planorbidae, and Physidae. A plausible explanation as to why Amnicola limosa was more abundantly found than some of the larger aquatic snails is that this species is found in large numbers in waters where there is an abundance of aquatic vegetation. A. limosa feeds primarily on the rich supply of diatoms harbored by such plants as Potamogeton spp., Chara sp., and Vallisneria sp.

Geographical Distribution

Figures 4,5,6,7,8,9, and 10 show the geographical distribution of the members of seven families of aquatic snails in Marquette County.

The data shows that the members of three families, namely Planorbidae, Physidae, and Amnicolidae, are widely distributed throughout the County. The majority of the species in these three families can live in many type of habitats, and this may account for their wide distribution throughout the County. Members of the families Ancylidae, Viviparidae, Valvatidae, and Lymnaeidae were not as widely distributed throughout Marquette County. Most of the freshwater limpets of the genus *Ferrissia* have become adapted to living on hard, silt-free substrates below the water surface in fast-flowing rivers and creeks and also require more searching because of their small size. The small size of limpets may explain why they were not encountered as often in this study as were other aquatic snails. Of the genus *Viviparus* in the family Viviparidae, only one species was collected during this study. No specimens of any species of *Viviparus* were recorded by Winslow (1926) for Michigan. Probably most of the present records of *Viviparus* from Michigan represent chance introductions from the contents of discarded aquaria (Clench,1962).

Table 2, pages 45-47, compares freshwater snails collected in Marquette County in this study and snails from Dickinson, and Menominee counties of Michigan's Upper Peninsula as reported by Baker (1922) and Goodrich (1939).

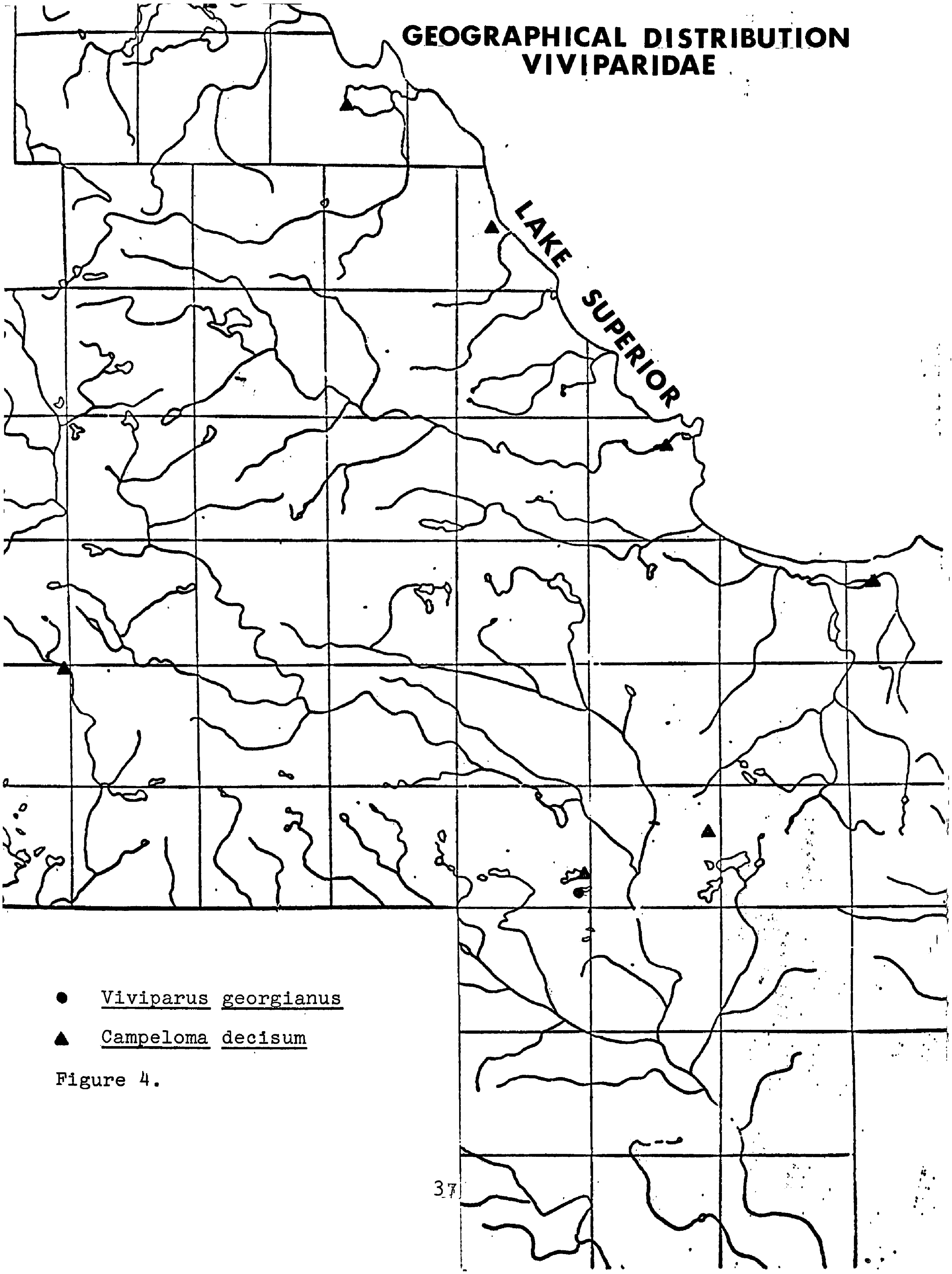

GEOGRAPHICAL DISTRIBUTION
VIVIPARIDAE
LAKE SUPERIOR
● Viviparus georgianus
▲ Campeloma decisum

Figure 4.

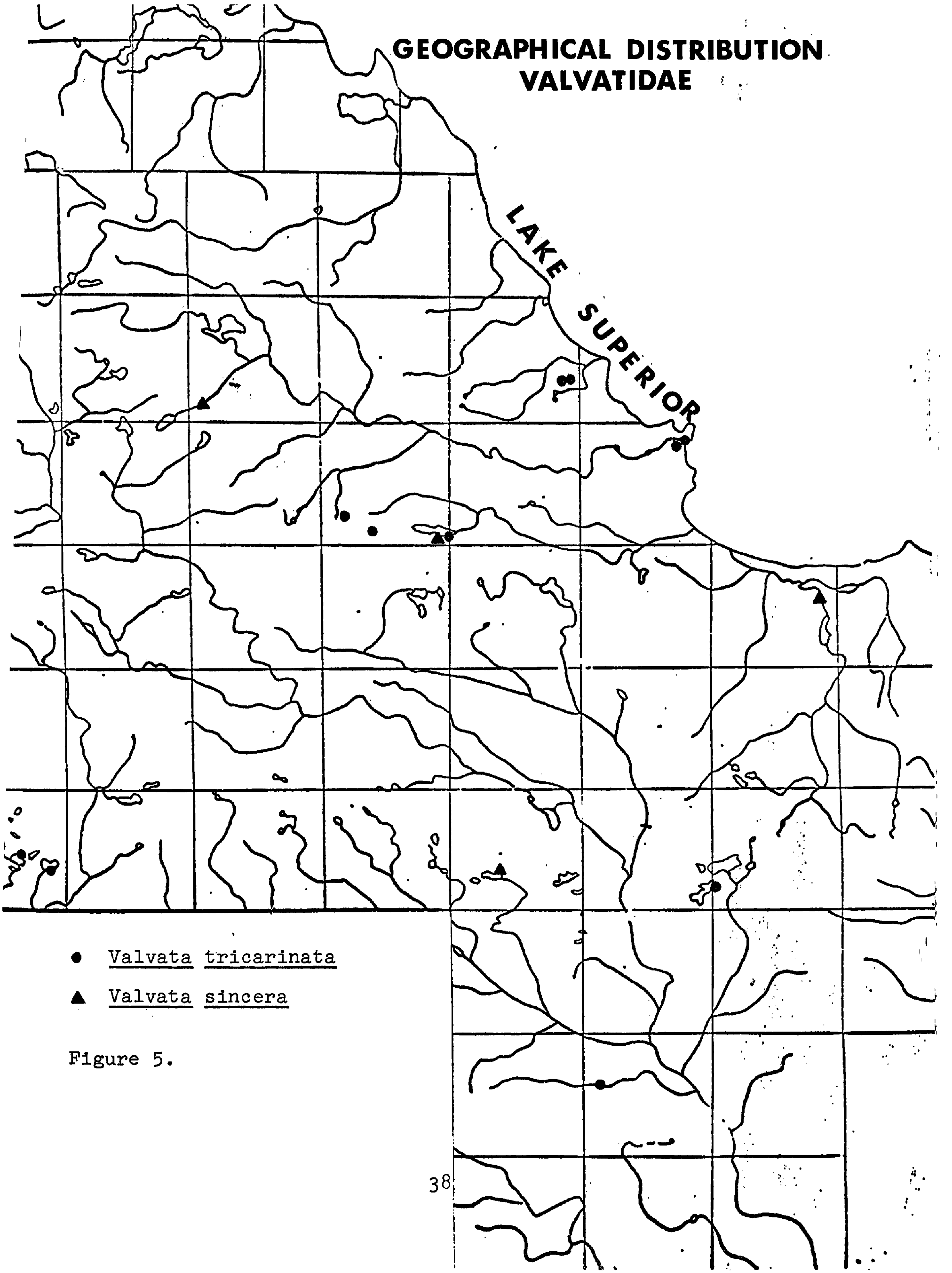

GEOGRAPHICAL DISTRIBUTION
VALVATIDAE
LAKE SUPERIOR
● Valvata tricarinata
▲ Valvata sincera

Figure 5.

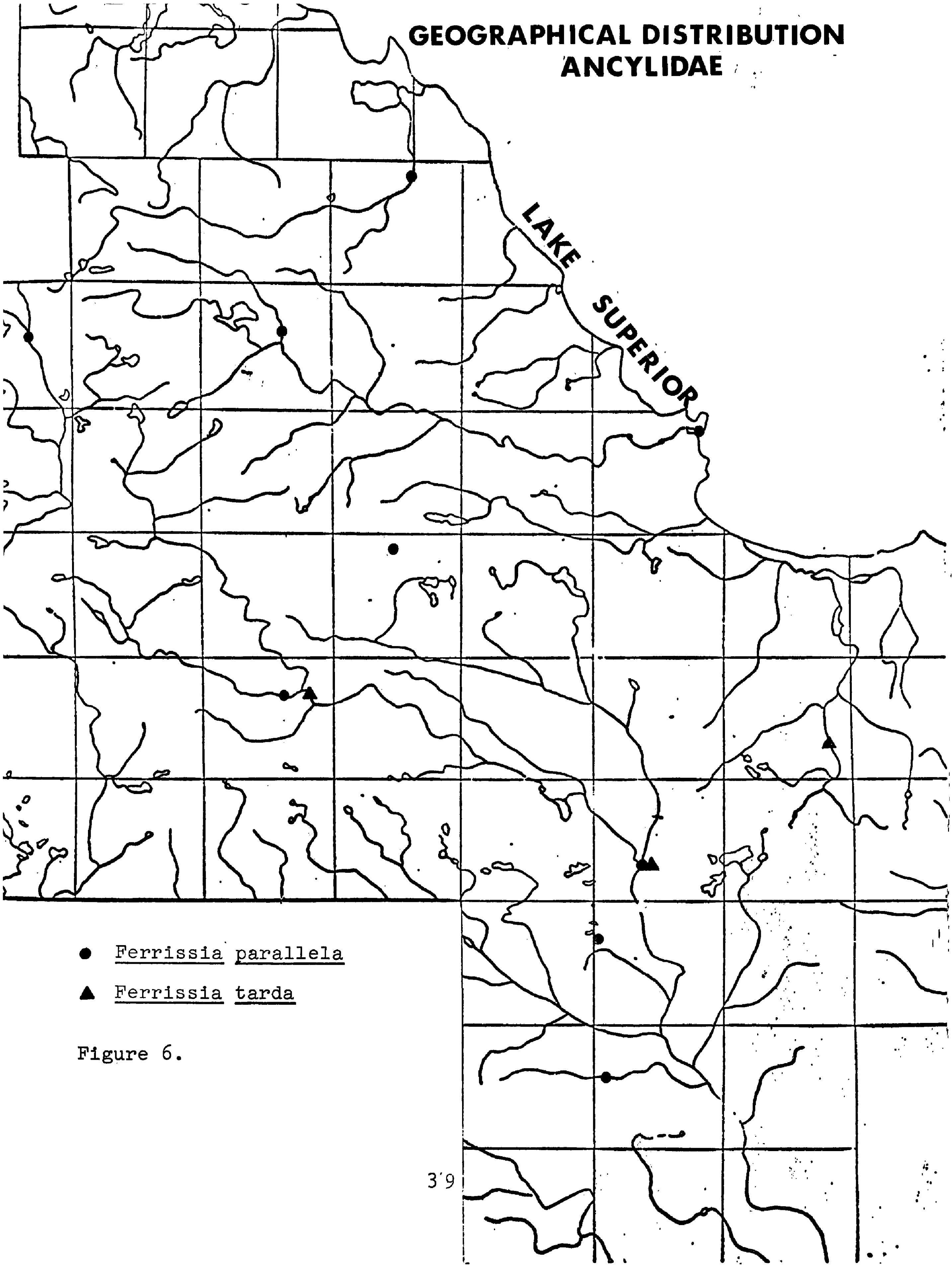

GEOGRAPHICAL DISTRIBUTION
ANCYLIDAE
LAKE SUPERIOR
● Ferrissia parallela
▲ Ferrissia tarda

Figure 6.

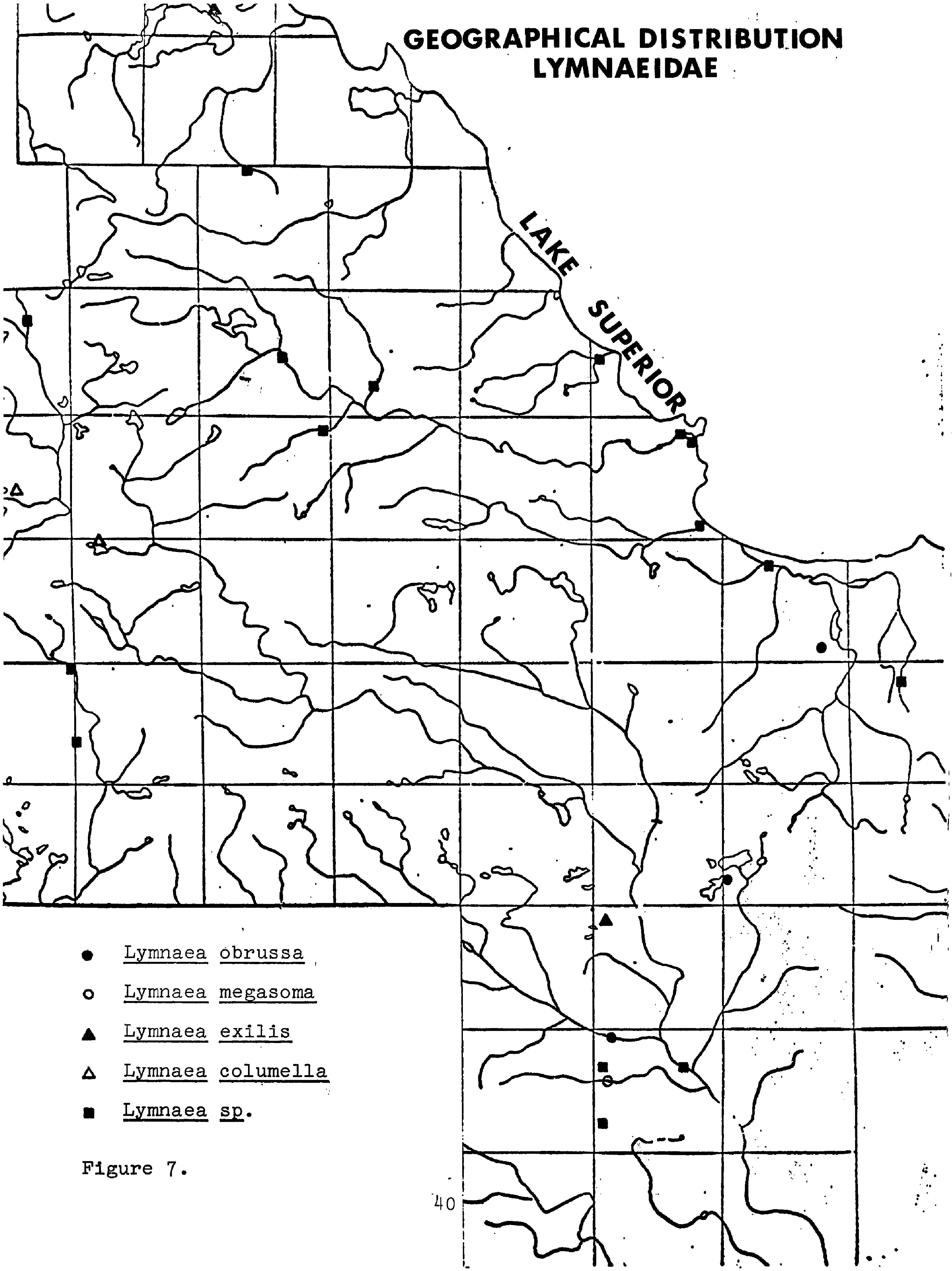

GEOGRAPHICAL DISTRIBUTION
LYMNAEIDAE
LAKE SUPERIOR
Lymnaea obrussa
Lymnaea megasoma
Lymnaea exilis
Lymnaea columella
Lymnaea sp.

Figure 7.

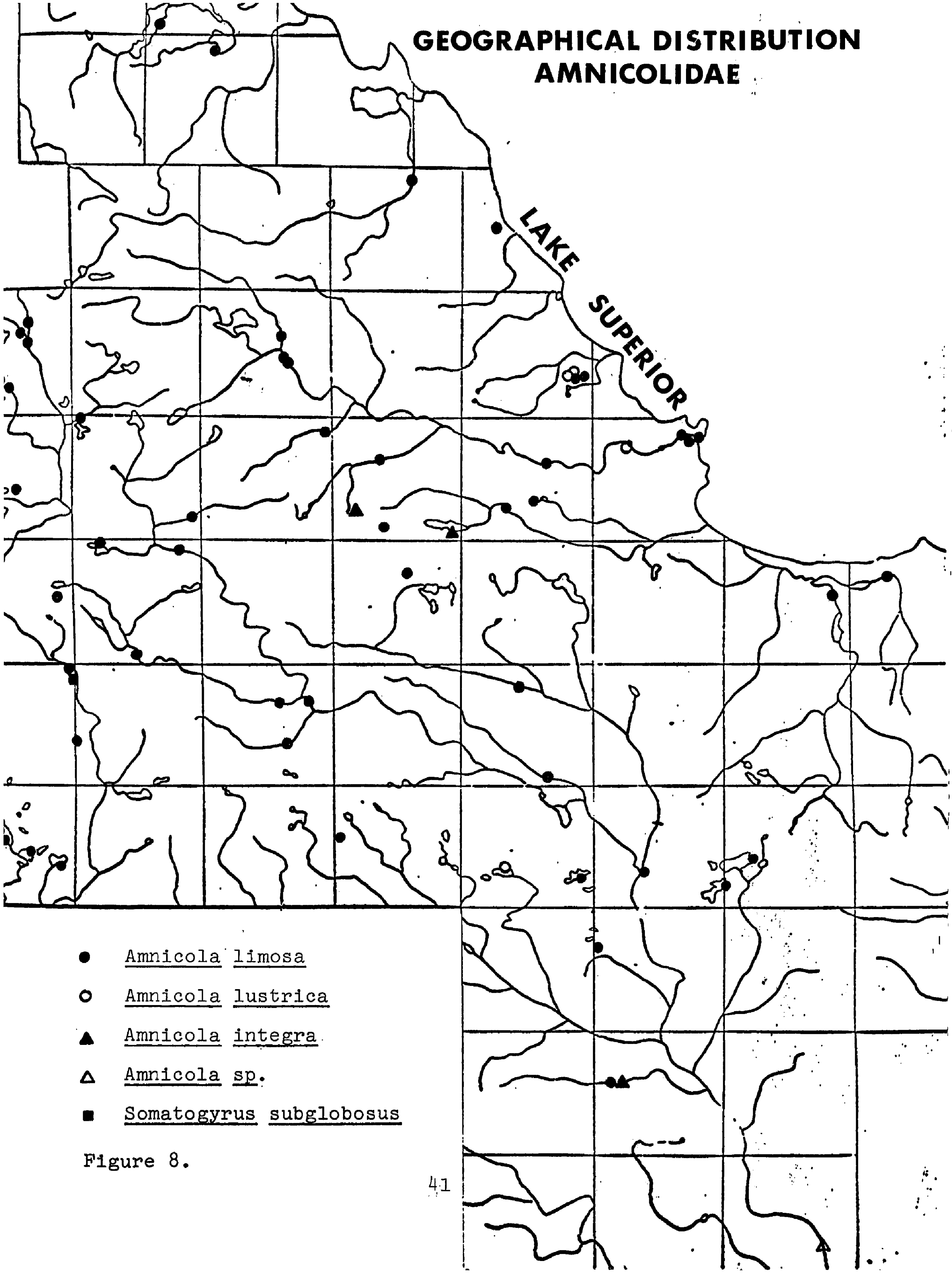
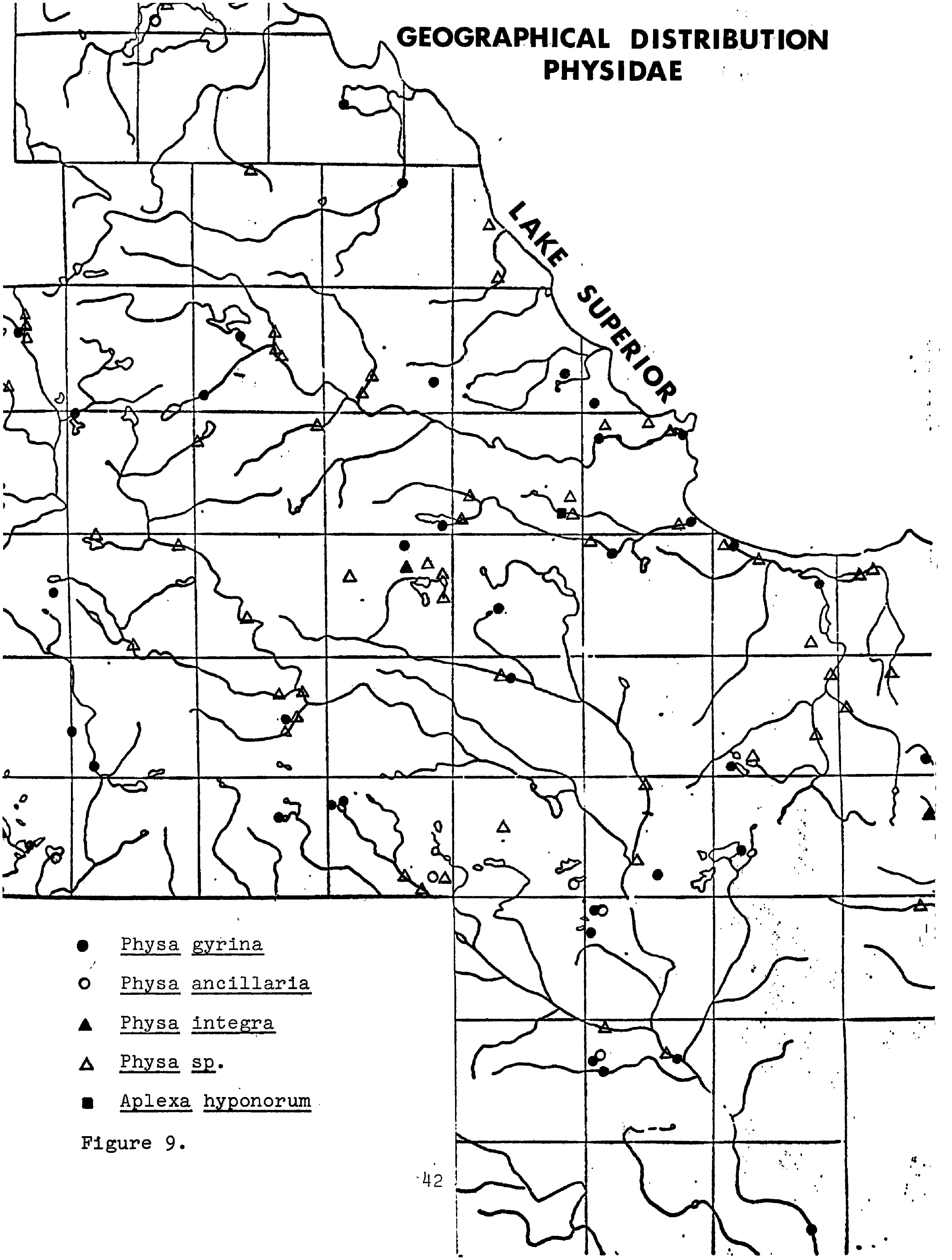

GEOGRAPHICAL DISTRIBUTION
AMNICOLIDAE
LAKE SUPERIOR
Amnicola limosa
Amnicola lustrica
Amnicola integra
Amnicola sp.
Somatogyrus subglobosus

Figure 8.



● Physa gyrina

○ Physa ancillaria

▲ Physa integra

△ Physa sp.

■ Aplexa hyponorum

Figure 9.

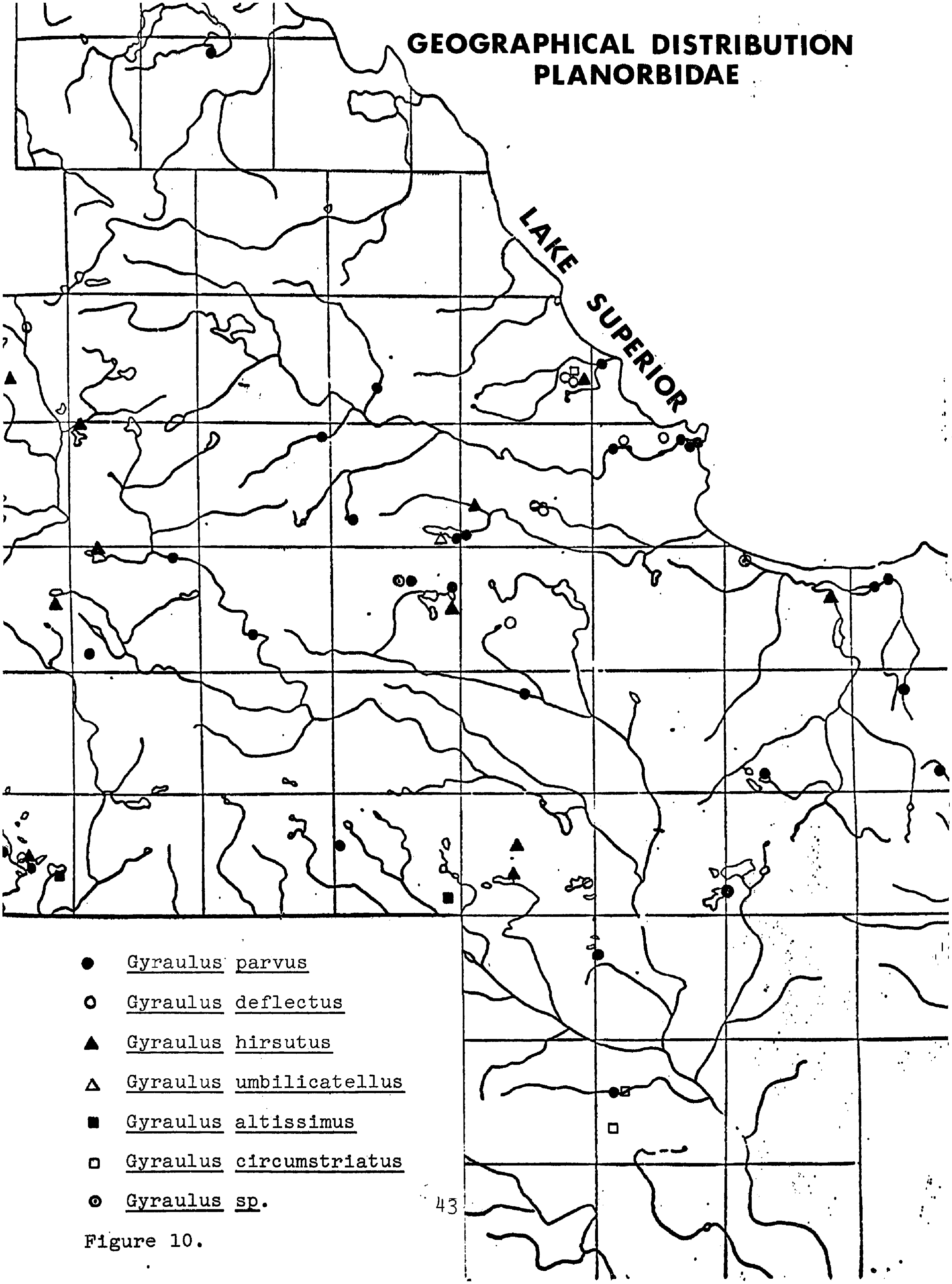

GEOGRAPHICAL DISTRIBUTION
PLANORBIDAE
LAKE SUPERIOR
● Gyraulus parvus
○ Gyraulus deflectus
▲ Gyraulus hirsutus
△ Gyraulus umbilicatellus
■ Gyraulus altissimus
□ Gyraulus circumstriatus
◎ Gyraulus sp.

Figure 10.

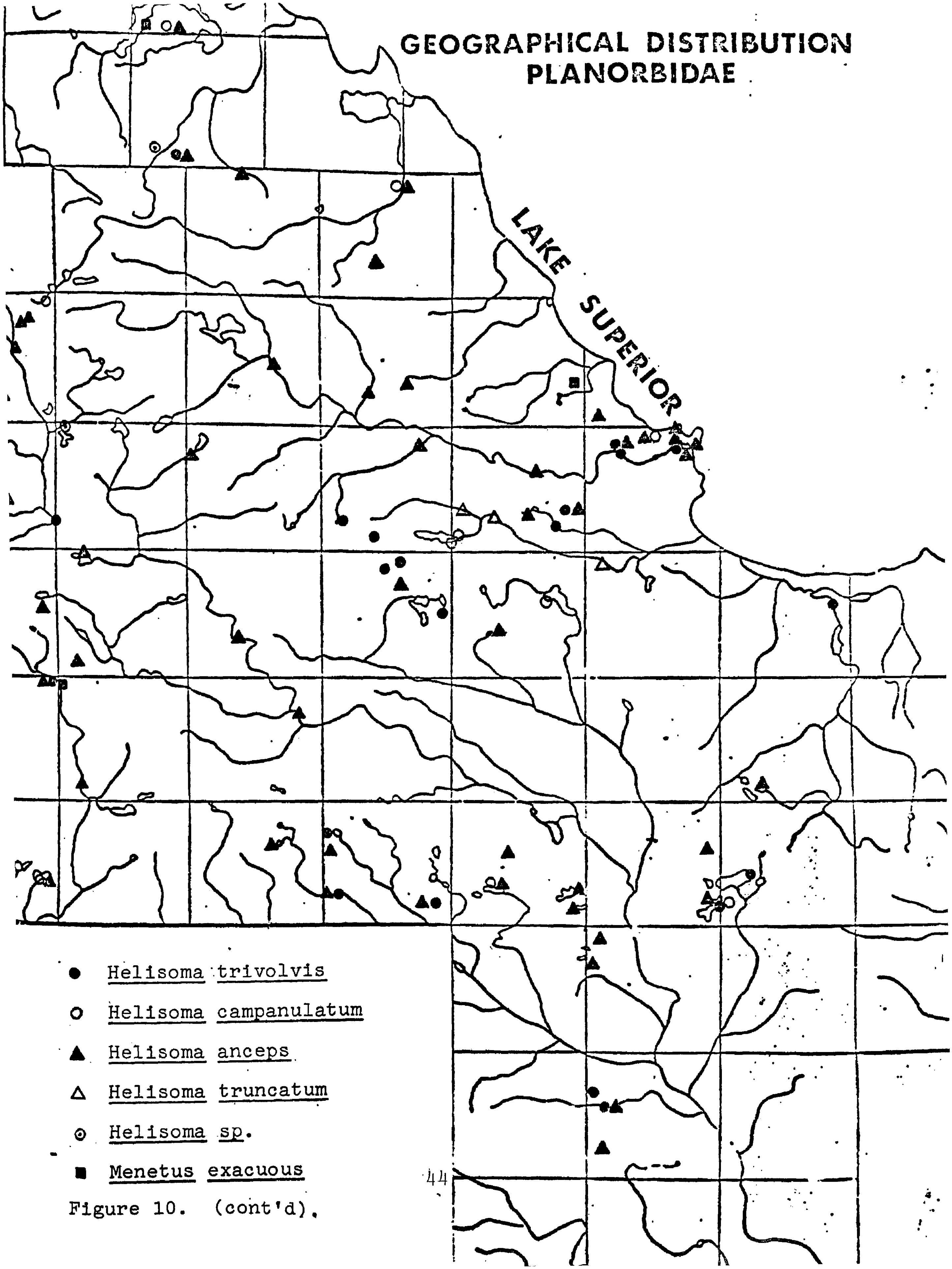


Figure 10. (cont'd).

Table 2. A Comparison of Aquatic Snails in Marquette, Dickinson, and Menominee Counties.

Species	Marquette County	Dickinson County '	Menominee County '
Lymnaea stagnalis appressa		X	X
Lymnaea megasoma	X	X	X
Lymnaea columella	X		
Lymnaea caperata			X
Lymnaea catascopium			X
Lymnaea humilis		X	
Lymnaea humilis modicella		X	
Lymnaea kirtlandiana		X	
Lymnaea lanceata			
Lymnaea obrussa		X	
Lymnaea obrussa decampi		X	X
Lymnaea obrussa exigua			X
Lymnaea obrussa peninsulae			
Lymnaea palustris			
Lymnaea exilis	X		
Helisoma antrosum (=anceps)	X	X	
Helisoma antrosum striatum		X	
Helisoma campanulatum		X	
Helisoma campanulatum minor		X	
Helisoma campanulatum rudentis		X	
Helisoma trivolvis	X	X	
Helisoma truncatum	X		

' From Goodrich(1939)

Table 2. (cont'd.)

Species	Marquette County	Dickinson County	Menominee County
Gyraulus deflectus	X	X	
Gyraulus altissimus	X		
Gyraulus hirsutus	X		
Gyraulus circumstriatus	X		
Gyraulus parvus	X	X	
Gyraulus umbilicatellus	X	X	
Menetus(=Promenetus) exacuous	X	X	
Planorbula armigera		X	
Physa ancillaria		X	
Physa ancillaria vinosa		X	
Physa elliptica			X
Physa gyrina		X	X
Physa heterostropha		X	
Physa integra		X	X
Physa michiganensis			X
Physa sayii		X	X
Physa walkeri		X	
Aplexa hyponorum	X	X	
Ferrissia parallela	X	X	
Ferrissia tarda	X		X
Campeloma decisum	X		X
Viviparus georgianus	X		
Valvata sincera	X	X	
Valvata sincera nylanderi		X	

Table 2. (cont'd.)

Species	Marquette County	Dickinson County'	Menominee County'
Valvata tricarinata	X	X	X
Valvata tricarinata confusa		X	
Valvata tricarinata simplex		X	
Valvata tricarinata unicarinata		X	
Somatogyrus subglobosus	X		
Amnicola limosa	X	X	
Amnicola limosa porata		X	
Amnicola lustrica		X	
Amnicola walkeri		X	
Pleurocera acuta			X
Goniobasis livescens			X

The data indicates, with a few exceptions, the presence of many of the same species in all three counties. The distribution of species of snails found in this study, in the Lower Peninsula of Michigan and throughout the Great Lakes States is as follows:

Campeloma decisum: This snail, which I found at eight locations throughout Marquette County, was collected from about thirty locations by Dr. John Lowe in the Upper Peninsula during the summer of 1927 (Goodrich and Van der Schalie, 1939). This species has also been taken by Lowe from the Dead River in Marquette County. *Campeloma decisum* is known to be common in Wisconsin, Minnesota, Indiana, but uncommon in northern Illinois (Baker, 1928).

Viviparus georgianus: This species, which I found in only one location, Little Shag Lake in Marquette County, has been collected in Wisconsin, Indiana, Ohio, and in Genesee and Shiawassee counties of Lower Michigan (Clench, 1962). It is quite common in central and northern Illinois. It is thought that the original northern and eastern limits of the range of this species was Illinois and northwest Indiana. It has invaded Ohio, Michigan, Wisconsin, Virginia, and New York since 1867. The specimens I collected are the first records from the Upper Peninsula.

Physa gyrina: This snail, which I found in 37 locations throughout Marquette County, is the most common *Physa* of Michigan and is found in its small lakes. It has been collected throughout this state (Van der Schalie and Berry, 1973) as well as in Indiana (Goodrich and Van der Schalie, 1944) and Wisconsin (Baker, 1928). This species is probably widely distributed throughout the Great Lake States since Baker (1928) describes the general distribution for *Physa gyrina* as occurring from the Arctic regions south to Alabama and Texas.

Physa integra: This species, which I found in only two locations in Marquette County, is considered to be the second commonest member of the genus in Michigan. It has been found in Dickinson, Delta, and Menominee counties of the Upper Peninsula as well as in the Lower Peninsula (Goodrich and Van der Schalie, 1939). The Physidae constitute a difficult family to differentiate by species, being extremely variable not simply between one colony of a species and another, but also within the colonies (Goodrich, 1932). This may explain why only a few species were reported in my study. The species may have been confused with some *Physa gyrina* specimens. *Physa integra* has also been collected in Indiana (Goodrich and Van der Schalie, 1944)

Physa ancillaria: I found this species in six locations throughout Marquette County. Goodrich (1939) reports that this snail has been collected from Lake Superior, Marquette County. *Physa ancillaria* has also been collected from Lake Erie, Point aux Peax, Monroe County; Brown Lake, Dickinson County; Manistee River, at Manistee; Lake Huron, Grinstone City, Huron County;

and in Saginaw Bay (Goodrich, 1932). It has also been reported in Wisconsin (Baker, 1928), and Indiana (Goodrich and Van der Schalie, 1944), and has often been confused with another species of Physa, namely, Physa sayii. Its' exact distribution throughout the Great Lakes States is therefore difficult to determine.

Helisoma trivolvis: I found this species in 22 locations throughout Marquette County. Collection of H. trivolvis or its subspecies by Lowe, Baker, and others have been made in brooks, creeks, rivers, ponds, and lakes of Baraga, Iron, Mackinac, Marquette, Menominee, and Schoolcraft counties of the Upper Peninsula (Goodrich and Van der Schalie, 1939) as well as in the Lower Peninsula (Van der Schalie and Berry, 1973), Wisconsin (Baker, 1928) and Indiana (Goodrich and Van der Schalie, 1944). It is considered to be among the most widespread of the freshwater pulmonates of North America.

Helisoma campanulatum: I found this species in eleven locations throughout Marquette County. It does not appear to be so generally distributed through the Upper Peninsula as Helisoma anceps. It has been collected in Menominee and Dickinson counties, and a subspecies, H. campanulatum minor, was taken from Perch Lake, Marquette County in 1928 by Dr. John Lowe (Goodrich and Van der Schalie, 1939). Other subspecies of Helisoma campanulatum have been found to occur in lakes of Houghton, Charlevoix, Chippewa, Huron, Luce, Lake, and Clare counties of Michigan (Goodrich, 1933). It is widely distributed throughout the central part of North America from Vermont west to North Dakota, and from Great Slave Lake south to Ohio and Illinois (Baker, 1928).

Helisoma anceps: I found this species in 54 locations throughout Marquette County. It has been recognized in Michigan as well as seven subspecies (Goodrich, 1932). *Helisoma anceps* is widely distributed throughout both the Upper and Lower Peninsulas (Van der Schalie and Berry, 1973), in Wisconsin, Illinois (Baker, 1928), Minnesota, Indiana, and Ohio (Van der Schalie and Berry, 1973).

Helisoma truncatum: This species, which I collected alive in only three locations in Marquette County, has been found dead in great numbers on the shores of Saginaw Bay, and has rarely been collected alive (Goodrich, 1932). It has been found in Northern Illinois and Wisconsin (Baker, 1928). Some specimens of *Helisoma truncatum* have often resembled some small lake forms of *Helisoma trivolvis* and young *pseudotrivolvis*, and this may explain in part why its distribution is not well known.

Somatogyrus subglobosus: I found this species only in the Michigamme River, in Marquette County. It is a deep water inhabitant and Goodrich (1932) collected it from Monroe and Saginaw counties of the Lower Peninsula of Michigan. Typical *S. subglobosus* have been seen only from Lake Michigan, Lake Erie, Lake Ontario, Oneida Lake, and Lake Winnebago (Baker, 1928). It is therefore thought to be confined to the Great Lakes region.

The distribution of *Somatogyrus subglobosus* in the Upper Peninsula is not known at this time.

Amnicola limosa: I found this species to be widely distributed throughout Marquette County. It is the most widely distributed species of the family Amnicolidae in Michigan (Berry, 1943). It has been collected from Ontonagon, Dickinson, Alger, Luce, and Schoolcraft counties of the Upper Peninsula of Michigan (Berry, 1943). This species is widely distributed throughout the Lower Peninsula (Berry, 1943). In Illinois, *Amnicola limosa* is recorded from the northern part of the state, especially in the northeastern part bordering Wisconsin (Baker, 1928). It has been found in Wisconsin (Baker, 1928), and in lakes of northern Indiana (Goodrich and Van der Schalie, 1944).

Amnicola lustrica: I found this species in five locations in Marquette County. It is the second most common amnicolid in Michigan (Berry, 1943). It is well distributed over the entire Lower Peninsula, and it has been collected from Dickinson, Luce, Schoolcraft, and Marquette Counties of the Upper Peninsula (Goodrich and Van der Schalie, 1939). This species may be present in other counties of the Upper Peninsula, but due to lack of distribution data this has not yet been determined. This species has been reported from Indiana, Illinois, Minnesota, and Ohio (Baker, 1928). Few specimens of *A. lustrica* were collected in Marquette County waters. This species as is true with many amnicolids is sometimes a difficult snail to identify with certainty because of the wide range of variation. The river form is often so different from the lake form that the two have been regarded as distinct species (Berry, 1943). This may account for the few numbers of specimens identified as *A. lustrica* during this study. *Amnicola lustrica* inhabits the same type of environment as does *A. limosa*, and therefore in a few cases may have been confused with *A. limosa* and identified as that species.

Amnicola integra: I found this species in only three locations in Marquette County. Although represented by scattered records over the entire state of Michigan, *A. integra* does not appear to be a common snail. It has been found in Houghton and Marquette counties in the Upper Peninsula (Berry, 1943). The shell of *A. integra* has been confused with that of three other species in Michigan, namely, *Amnicola limosa* (Say), juvenile forms of *Bulimus tentaculatus* (Linnaeus), and *Campeloma integrum* (Say) (Berry, 1943). *Amnicola integra* has been found in Illinois, Indiana, and Wisconsin (Baker, 1928).

Ferrissia parallela: I found this species in nine locations throughout Marquette County. *Ferrissia parallela* is a freshwater limpet of the family Ancylidae that is probably well distributed throughout the Upper Peninsula, since previous collections of it have been made in Houghton, Baraga, Keweenaw, Mackinac, Marquette, Ontonagon, and Schoolcraft counties (Goodrich and Van der Schalie, 1939). This species has also been reported in

Minnesota, northern Ohio, Indiana, northeastern Wisconsin, and the northeastern part of Illinois (Baker, 1928). It is perhaps a species of northern distribution.

Ferrissia tarda: I found this freshwater limpet in only three locations in Marquette County. It also has been collected from Baraga, Houghton, and Menominee counties of the Upper Peninsula (Goodrich and Van der Schalie, 1939). Its distribution also includes the Lower Peninsula of Michigan, Illinois, Ohio, Wisconsin (Baker, 1928), and also Indiana (Goodrich and Van der Schalie, 1944).

Aplexa hyponorum: One specimen of this species was found in Morgan Creek in Marquette County. Lowe collected it in Menominee County, Mackinac County, and Schoolcraft County in the Upper Peninsula (Goodrich and Van der Schalie, 1939). Aplexa is commonly associated with Physa gyrina in wood pools, stagnant ditches, and swamps and may be mistaken as belonging to the genus Physa. The species has been collected in Wisconsin and Ohio (Baker, 1928), and is also in Indiana (Goodrich and Van der Schalie, 1944). No previous distribution record of this species occurring in Marquette County is known.

Lymnaea obrussa: I found twelve specimens of this species in three locations in Marquette County. L. obrussa is considered to be one of the more common small lymnaeas in Michigan (Goodrich, 1932). Few specimens have been collected in the Upper Peninsula. It has been found in Schoolcraft, Mackinac, Dickinson, and Delta counties of the Upper Peninsula, and in Southern Monroe County of the Lower Peninsula (Goodrich and Van der Schalie, 1939; Goodrich, 1932). Several subspecies have been found in Menominee, Alger, and Marquette counties. Typical L. obrussa, however, has been found in the northern and eastern part of Wisconsin (Baker, 1928) and in Indiana (Goodrich and Van der Schalie, 1944).

Lymnaea columella: Five specimens collected from western Marquette County constitute the first known records of this species in the Upper Peninsula. It has been found in northern Wisconsin, however, by J. P. Morrison (1932) and in Iron Lake in Lenawee County in Lower Michigan (Goodrich, 1932). The species has also been found in Minnesota (Baker, 1928), and in Indiana (Goodrich and Van der Schalie, 1944).

Lymnaea megasoma: I found only two specimens of this species in the Little West Branch of the Escanaba River in Marquette County. Most of the Michigan records of this species are from the Upper Peninsula (Goodrich, 1932), with records from Menominee, Dickinson, and Marquette counties (Goodrich and Van der Schalie, 1939). In the Lower Peninsula, no specimens have been reported from south of Houghton and Higgins Lakes in Roscommon County, although this species has been found in northern Ohio (Goodrich, 1932) and Indiana, northern and central Wisconsin, and in Minnesota (Goodrich and Van der Schalie, 1944). It is a species of northern distribution.

Lymnaea exilis: The eleven specimens I collected from both northern and southern Marquette County are the first records from the Upper Peninsula. It has been collected in northern Wisconsin, northern Ohio, and Minnesota (Baker,1928). It has been found in Antrim County of Michigan's Lower Peninsula, and also in northern Indiana (Goodrich, 1932). In this study, *Lymnaea exilis* was found in Bilsky and Middle Pine Lakes in Marquette County. It is a species of northern distribution.

Promenetus exacuous: I found only five specimens of this species in three locations in Marquette County. Only a few distribution records for species in Michigan are known. Previously its presence in the Upper Peninsula had only been reported for Dickinson County. It has been found mostly in the southwestern part of the Lower Peninsula, but occasionally in the southeastern area (Goodrich, 1932). *P. exacuous* is widely distributed over the state of Wisconsin (Baker, 1928), and it is known from Indiana (Goodrich and Van der Schalie, 1944).

Valvata tricarinata: I found this species in eleven locations throughout Marquette County. It seems to be widely distributed throughout the Upper Peninsula. It has been collected from Menominee, Dickinson, Marquette, and Luce counties of the Upper Peninsula (Goodrich and Van der Schalie, 1939). Specimens have also been taken from Lower Michigan (Goodrich and Van der Schalie, 1939). The species is also found in Indiana, Ohio, and Wisconsin (Baker, 1928).

Valvata sincera: This species was collected from only four locations in Marquette County. It has been collected in a branch of the Dead River, Marquette County, and from lakes of Dickinson, Keweenaw, Marquette, Schoolcraft and Mackinac counties of the Upper Peninsula (Goodrich and Van der Schalie, 1939). *Valvata sincera* also occurs in Lower Michigan with records from Lake County (Goodrich, 1932). This species has also been found in Indiana and Wisconsin, but has not been reported from Illinois (Baker, 1928). It appears to be a northern species (Baker, 1928).

Gyraulus parvus: I found this species in 28 locations throughout Marquette County. It is well distributed throughout the Upper Peninsula of Michigan (Goodrich and Van der Schalie, 1939). It occurs in Minnesota, Illinois, Wisconsin, Indiana, and Ohio (Baker, 1928).

Gyraulus deflectus: This species was collected from ten locations in Marquette County. *G. deflectus* has been collected in Bat and Perch Lakes, Marquette County and in Joe's Lake, Alger County (Goodrich and Van der Schalie, 1939). It has also been found in Dickinson, Baraga, Luce, and Delta counties of the Upper Peninsula, and it is common throughout Lower Michigan (Goodrich and Van der Schalie, 1939). It also occurs in Indiana

(Goodrich and Van der Schalie, 1944) and in Wisconsin (Baker, 1928).

Gyraulus hirsutus: This species, which I found in eleven locations throughout Marquette County, has been collected in Marquette, Menominee, Schoolcraft, Chippewa, Baraga, Houghton, Keweenaw, Ontonagon, Dickinson, and Mackinac counties of the Upper Peninsula (Goodrich and Van der Schalie, 1939). It also occurs in Minnesota, Ohio, northern Wisconsin (Baker, 1928), and Indiana (Goodrich and Van der Schalie, 1944).

Gyraulus umbilicatellus: One specimen of this species was found in Teal Lake in Marquette County. It does not occur as frequently in Michigan as Gyraulus parvus or Gyraulus deflectus. It is known only from Sand Point, Huron County; Brown Lake, Dickinson County; and White Pigeon, St. Joseph County (Goodrich, 1932). It is also known from Minnesota, Illinois, Indiana, and Wisconsin (Baker, 1928).

Gyraulus altissimus: The three specimens I collected from southwest Marquette County are the first known records of this species for the Upper Peninsula. Only shells were found in this study. Baker (1928) believes that this snail is evolutionarily a predecessor of Gyraulus parvus. Its' distribution is from pleistocene deposits in Ohio, Indiana, Illinois, Michigan, and Wisconsin (Baker, 1928). In Wisconsin, G. altissimus has been found mainly in bodies of water where there are marl deposits on the bottom (Baker, 1928). During this study the shells of this species were found in marl deposits on the bottoms of Witch Lake and Charley Lakes in Marquette County.

Gyraulus circumstriatus: Thirteen specimens collected from three locations in Marquette County constitute the first records of this species in the Upper Peninsula. *G. circumstriatus* has been found in northeastern Wisconsin close to the Upper Peninsula (Goodrich and Van der Schalie, 1939). Baker (1928) describes this species general distribution as occurring from Connecticut, west to Wisconsin. The exact limits, especially north and south are not well known. *Gyraulus circumstriatus* has also been reported in Indiana (Goodrich and Van der Schalie, 1944).

It should be noted further that the lack of distribution records for some of the previously mentioned species is undoubtedly due to a lack of thorough investigation rather than a lack of species present. It is difficult to explain the presence or absence of a species in a certain location because distribution records are so incomplete.

Snail Distribution in Relation to Ecological Factors

Chemical Factors

The only chemical factor tested for in this study was pH. A listing of the sites visited and the pH is shown in Appendix Table A4 on pages 131-140. The pH range, mean, and standard deviation found for twenty-three species are illustrated in Table 3 on page 61. Figure 11, page 62, shows the occurrence of twenty-nine species of aquatic snails in relation to the pH of the waters sampled. Most of the pH readings obtained for Marquette County waters were in the alkaline range. Although there were a number of snails taken from acidic waters, these were usually few in number and in most cases were empty shells. Figure 12, page 63, shows the average number of species of snails collected in relation to pH of water. Figure 13, page 64, shows the average number of individual snails collected in relation to pH of water.

The data show that aquatic snails are common in alkaline waters and that the mean pH for most species was 7.2. The diversity of aquatic snails also seems to be related to the pH of the water. Figure 12 shows that a pH range of 6.9 to 8.0 supports more species than does the pH range of 6.2 to 6.9. Figure 13 indicates that the snails collected in Marquette County waters were most abundant in the pH range of 6.9 to 8.0, with the exception that at a pH of 6.4 the average number of individual snails collected was thirty-two. This value reflects the large number of *Amnicola limosa* snails that were collected

Table 3. The pH Range, Mean, and Standard Deviation for Twenty-Three Species of Aquatic Snails. (Both Lentic and Lotic Waters Considered).

Species	Number of Samples	Range (±0.1)	Mean	Standard Deviation
Campeloma decisum	8	6.8-7.4	7.1	0.2
Physa gyrina	33	6.3-7.5	7.1	0.3
Physa ancillaria	6	7.0-8.0	7.4	0.4
Physa integra	2	7.2-7.4	7.3	0.1
Helisoma trivolvis	19	6.2-8.0	7.1	0.4
Helisoma campanulatum	11	6.4-7.5	7.2	0.3
Helisoma anceps	49	6.4-8.0	7.1	0.3
Ferrissia parallela	8	7.1-7.6	7.3	0.2
Ferrissia tarda	3	7.0-7.3	7.2	0.2
Lymnaea obrussa	3	7.1-7.2	7.2	0.1
Lymnaea columella	2	6.6-7.3	6.9	0.5
Lymnaea exilis	2	7.2-7.3	7.3	0.1
Promenetus exacuous	3	7.0-7.3	7.1	0.2
Valvata tricarinata	9	7.1-7.5	7.3	0.1
Valvata sincera	4	6.4-7.3	7.0	0.4
Amnicola limosa	46	6.4-7.5	7.1	0.3
Amnicola lustrica	5	7.2-7.5	7.3	0.1
Amnicola integra	3	7.0-7.2	7.1	0.1
Gyraulus parvus	25	6.7-7.5	7.1	0.2
Gyraulus deflectus	9	6.8-7.5	7.1	0.2
Gyraulus hirsutus	10	6.4-7.5	7.0	0.3
Gyraulus altissimus	2	7.4-8.0	7.7	0.4
Gyraulus circumstriatus	3	7.1-7.3	7.2	0.1

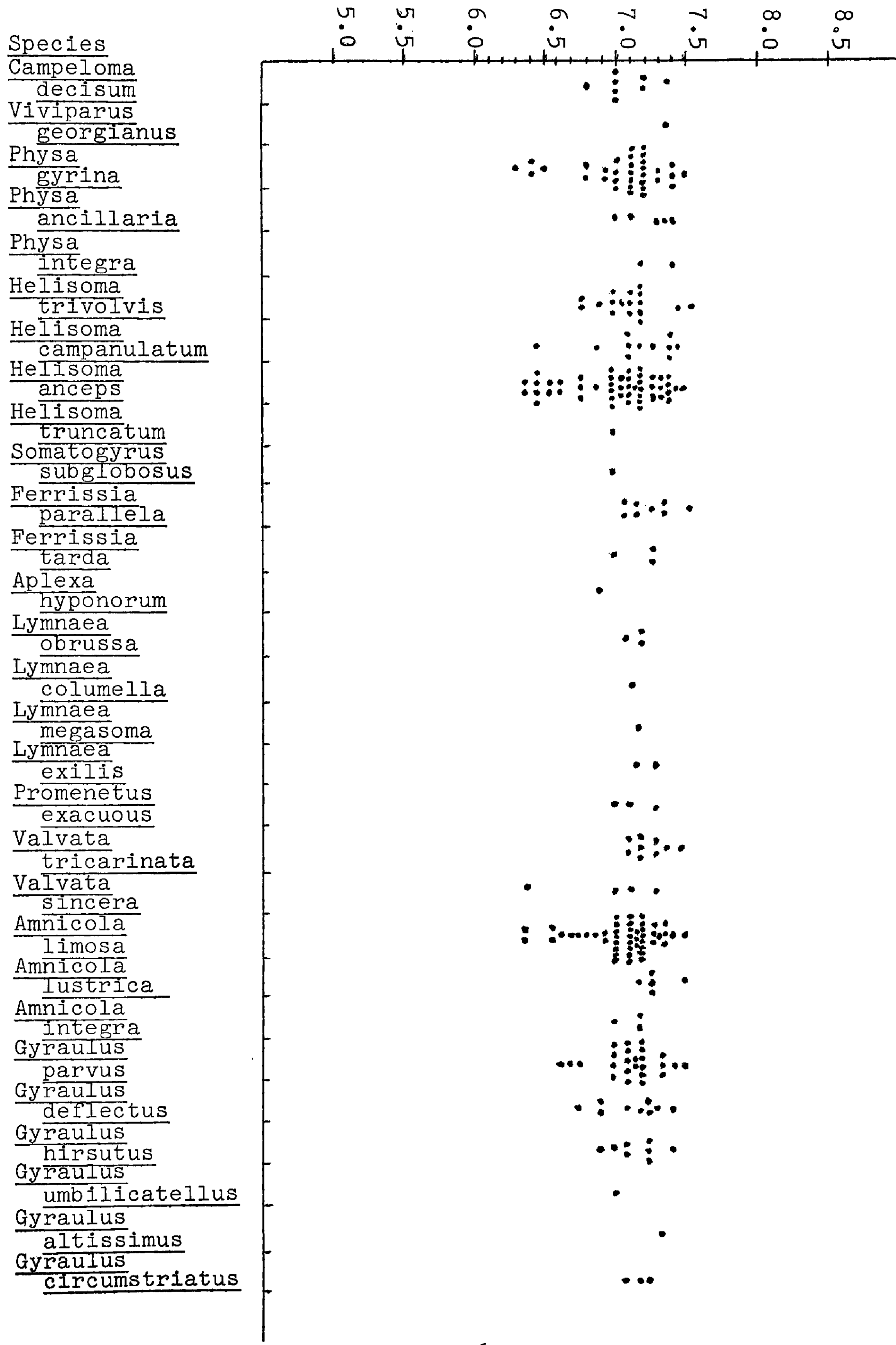


Fig. 11. Occurrence of twenty-nine species of aquatic snails in relation to the pH of the water.

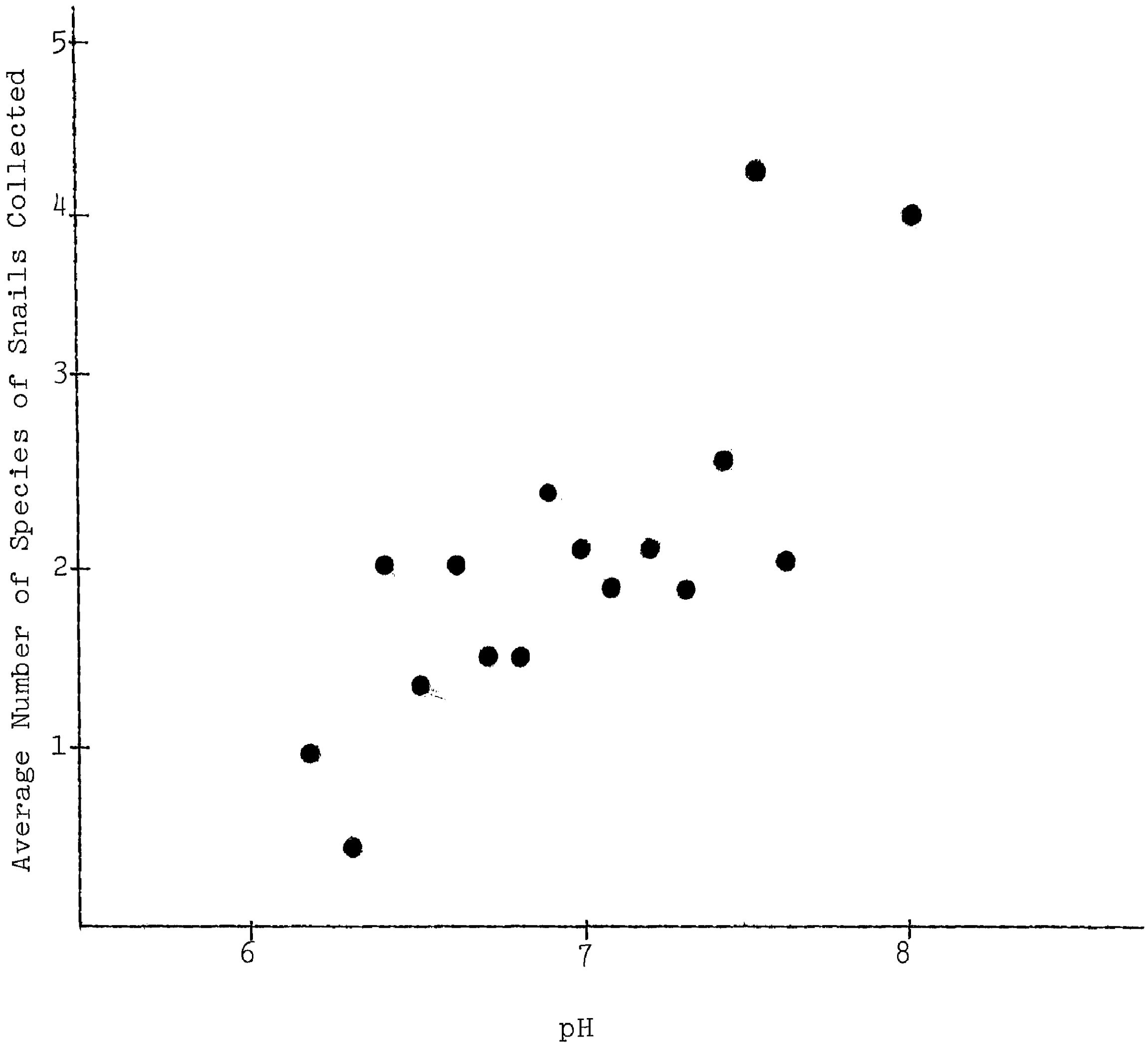


Figure 12. The Average Number of Species of Aquatic Snails Collected in Relation to pH of Water.

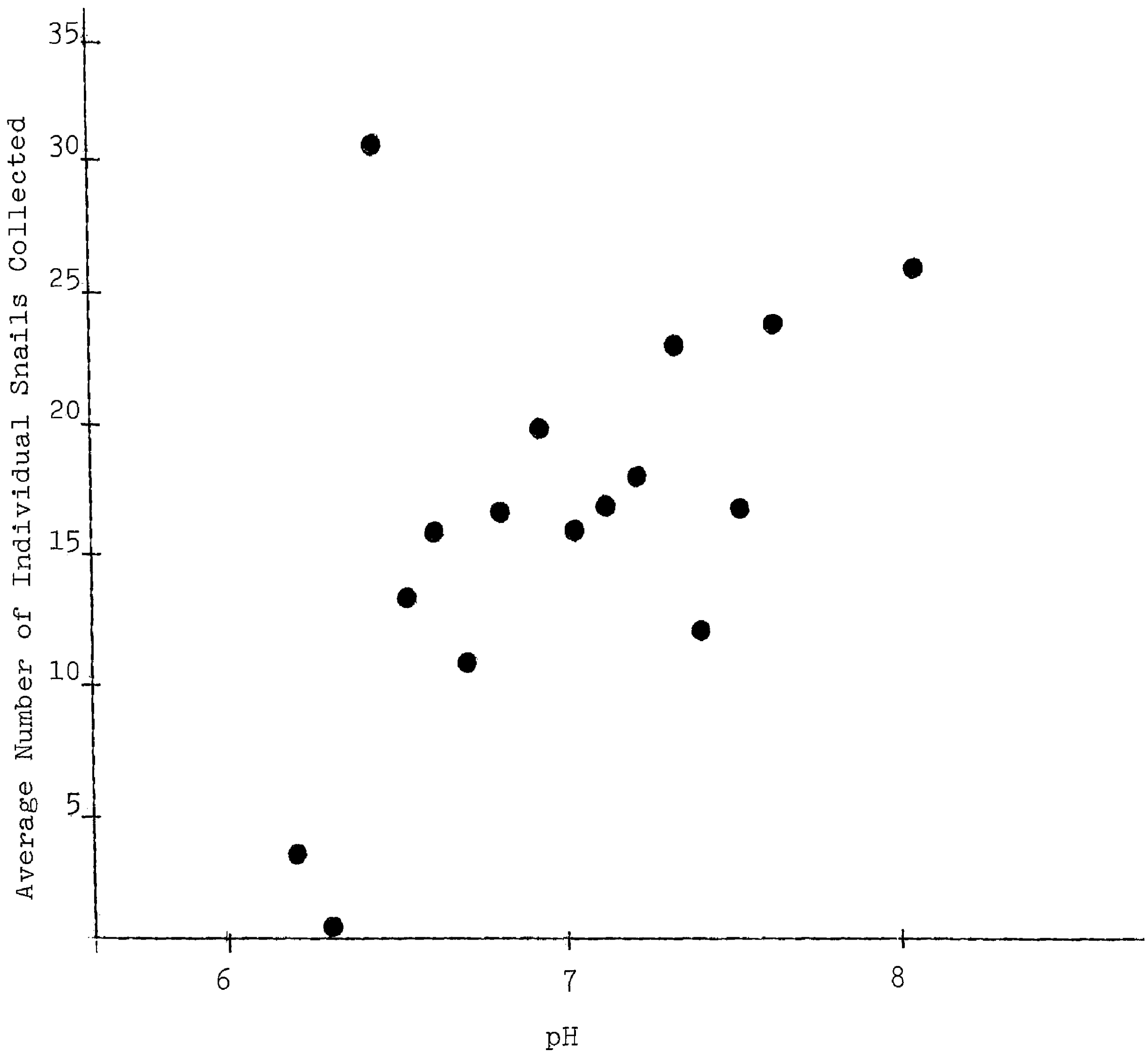


Figure 13. The Average Number of Individual Snails Collected in Relation to pH of Water.

at two of the five locations having a pH of 6.4. Attempts have been made to relate molluscan distribution directly with pH. In Britain, few mollusks live at pH lower than that of 6.0 (Boycott, 1936). However, clearer correlation is found with calcium content or total alkalinity. The pH, or hydrogen ion concentration, is clearly associated with, and partly determined by, the carbon dioxide content, and bodies of water low in carbonates are usually toward the acid side of the scale (below pH 7.0), while those high in carbonates are almost always alkaline (Pennak, 1953). Hyman (1967) mentions also that it has usually been stated that freshwater snails are absent from acid waters, such as those of peat bogs at pH 6 or below.

It should be noted that during this study aquatic snails were collected from only one bog environment. Other bog habitats were visited during this study, but no aquatic snails were found. The bogs, which were associated with Cranberry Lake (T 45N - R30W - S10), Little Mud Lake (T 48N - R25W -S53), and Baraga Creek (T49N - R30W - S10), each had a pH of 6.2. Only a single specimen of Helisoma anceps and of Physa gyrina were collected at the bog associated with Wetmore's Pond. The shells appeared to be somewhat smaller and thinner than other snails of the same species collected throughout this study. Fromming, however, claims this scarcity or absence of freshwater snails from acid waters, is due to the scarcity of suitable food rather than to the acidity as such (Hyman, 1967). He has collected common European freshwater operculates in waters ranging from pH 6.3 to 8.3 and denies that the shells are smaller in acidic waters. The snails collected at the bog environment (Helisoma anceps and Physa gyrina) were small in size for those genera, but these specimens may have been immature. According to Boycott (1936), freshwater gastropods require a minimum concentration of 20 mg. of calcium per liter for the growth of their shells.

Amnicola limosa was found in waters ranging in pH from 6.4 to 7.5. Pennak (1953) states that a subspecies, (Amnicola limosa porata (Say), has been found in waters ranging in pH from 5.7 to 8.3. In general, however, aquatic snails are uncommon in lakes and streams whose surface waters are more acidic than pH 6.2(Pennak, 1953). Pennak(1953) believes that it follows then that the great majority of species and the largest numbers of individuals occur under alkaline conditions. The data obtained from the present study supports Pennak's conclusion.

All of the Valvatidae and nearly all of the lymnaeidae have been confined to waters having pH readings of 7.0 or above(Pennak, 1953). In the present study, Valvata tricarinata was found in waters ranging in pH from 7.2 to 7.5. Harman(1968) found the pH range for Valvata tricarinata in central New York state to be 7.3-8.3.

Ferrissia parallela has been found in waters ranging from pH 6.0 to 8.4(Pennak, 1953). In the present study, this species was found in running waters ranging from pH 7.1 to 7.6. Morrison (1932) found Helisoma anceps in Wisconsin waters ranging in pH from 6.0 to 8.0. This species was very abundant and occurred frequently in Marquette County waters ranging in pH from 6.4 to 8.0. H. anceps was found in lakes, ponds, rivers, creeks, and a bog in Marquette County during this study. Gyraulus altissimus was collected only at two locations in Marquette County, namely Witch Lake and Charleys' Lake. These lakes both have very alkaline waters, and marl deposits on the bottom. Because G. altissimus is an extinct species, it is probable that the pH of these lakes has changed since the snails' existence as a living animal. Therefore, it cannot be assumed that G. altissimus lived in very alkaline waters.

The majority of the snails collected were found in waters which ranged in pH from 6.5 to 7.5. At three locations in Marquette County, a large number of species were collected in waters which had a pH in the 7.1 to 7.5 range. Ten species were found in the Little West Branch of the Escanaba River, which had a pH reading of 7.2. Eight species were collected from Horseshoe Lake (station #57), with a pH reading of 7.5. Seven species were taken from Bass Lake where the pH reading was 7.1. Although the frequency of occurrence of aquatic snails in acid waters was much less than in alkaline waters, most species were encountered over a wide range of pH.

It is difficult to draw conclusions regarding the distribution of aquatic snails in relation to only one chemical characteristic of the water. It seems apparent, however, that the pH of water does have an effect upon the distribution of aquatic snails indirectly by affecting the food organisms that are able to survive in such waters. Waters that are low in calcium may also limit the abundance and distribution of aquatic snails, since these animals require calcium for the construction and growth of their shell. It should also be mentioned that changes in pH with seasons may have a slight effect on regulating the abundance and distribution of snails by affecting the growth of certain plants or food organisms. In smaller lakes and ponds, variations in pH on different days and at different times of the same day may take place.

These diurnal changes in pH may be a result of photosynthesis and respiratory processes of some organisms occurring in those waters (Welch, 1952).

Physical Factors

Lentic versus Lotic Waters:

Figure 14 shows the percentage of occurrence of twenty-nine species of aquatic snails in one-hundred and twenty-four lotic and twenty-five lentic waters in Marquette County. A comparison between the occurrence of aquatic snails in these two types of waters is considered first by subclasses and then by families as follows:

Prosobranchs or Operculates

The freshwater gastropoda comprise two distinct subclasses, the Prosobranchiata and the Pulmonata. The Prosobranchiata are represented in Marquette County waters by the families Valvatidae, Viviparidae, and Amnicolidae. The Prosobranchs are characterized by separate sexes (except Valvatidae), the presence of opercula, and true gills. Boycott (1936) found that freshwater prosobranchs, which must utilize their gills in respiration, are limited to waters of higher oxygen content than are the pulmonates, which can come to the surface and breathe atmospheric air. The Prosobranchs are therefore restricted mainly to lakes and large permanent streams with relatively high oxygen levels. In bog, swamp, and some pond environments, oxygen content frequently drops to low levels, and therefore is unsuitable for Prosobranchs (Harman, 1968).

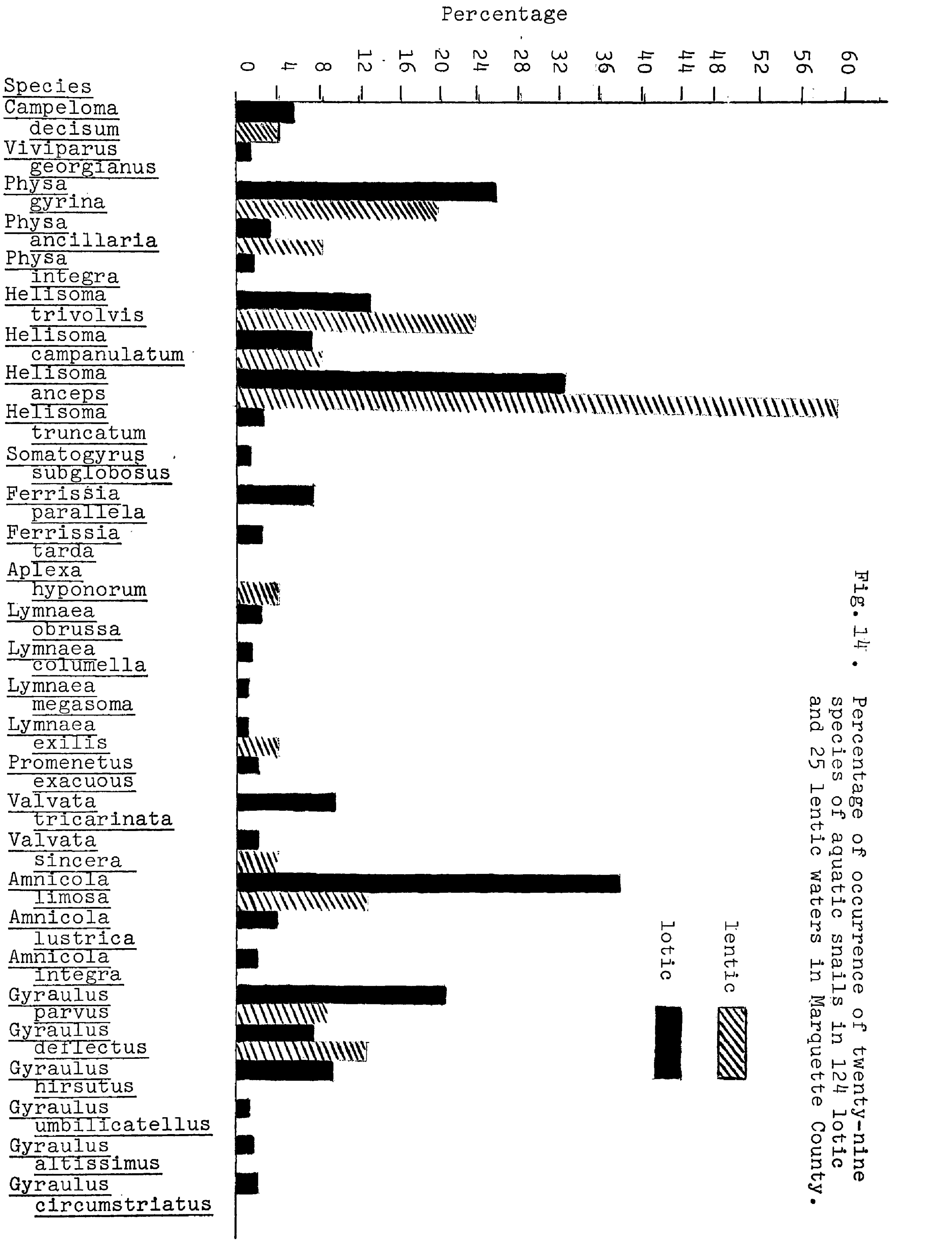


Fig. 14. Percentage of occurrence of twenty-nine species of aquatic snails in 124 lotic and 25 lentic waters in Marquette County.

Valvatidae: Valvata tricarinata was found in 9% of the lotic waters investigated in Marquette County and in none of the lentic waters. Valvata sincera was encountered in 2.4% of the lotic waters and 4.0% of the lentic waters. The members of the family Valvatidae have developed gills that can be oriented completely outside of their mantle cavities and are therefore less affected than other prosobranchs by fouling materials close to the substrate (Baker, 1928; Harman, 1968). For this reason, it is reasonable to assume that Valvata may be found in both lotic and lentic waters.

Amnicolidae: Amnicola limosa was found in 38% of the 124 lotic waters sampled and in 13% of the 25 lentic habitats during the present study. This species was typically abundant where there were thick beds of stoneworts (Chara sp.), pondweeds (Potamogeton spp), and waterweed (Anacharis sp.). Both Amnicola integra and Amnicola lustrica were found only in lotic waters. It is by no means implied that these snails are not present in lentic waters, since they have been observed in quiet bodies of water in Monroe County, Michigan (Berry, 1943). The amnicolids are usually found in permanent waters, lotic or lentic, that contain quantities of aquatic plants (Harman, 1968).

Viviparidae: Campeloma decisum was about 2.0% more common in lotic waters than in lentic waters. This percentage is small and probably inconsequential. Baker (1928) cites this species as primarily an inhabitant of rivers, but Harman (1968) reported collecting Campeloma decisum in both lotic and lentic habitats in central New York state. Hyman (1967) states that the Viviparidae are limited to freshwater, inhabiting lakes, ponds, marshes, streams, and wood pools.

Since only nine specimens of Viviparus georgianus were collected from one location in Marquette County, it is difficult to determine whether this species occurs more or less frequently in lotic or lentic waters. In this study these snails were collected from Little Shag Lake in shallow water on a sandy bottom. Baker (1928) reports finding this species in both lakes and rivers on mud and sand bottoms in shallow waters in protected situations.

Pulmonata

The families constituting the subclass Pulmonata do not have gills, but obtain oxygen through a mantle cavity that is used as a lung. They are also characterized by being hermaphroditic, and possessing no opercula. The Pulmonata are represented by the families Lymnaeidae, Physidae, Planorbidae, and Ancylidae. These snails are familiar members of the fauna of lakes, ponds, ditches, and other kinds of standing water (Hyman, 1967).

Lymnaeidae: All of the lymnaeids collected except Lymnaea exilis were found in lotic waters. Lymnaea exilis has been found in ponds, and stagnant pools in Wisconsin (Baker, 1928). It appears therefore that lymnaeids can inhabit both lotic and lentic environments. The members of the Lymnaeidae depend entirely on the rich vascular tissues of otherwise simple mantle cavities for respiration. This "lung" may be filled with surface air periodically or may be filled with water (Morton and Yonge, 1964). It appears that pulmonates that occur at great depths and those that remain submerged for long periods of time fill the pulmonary cavity with water and use it as a gill (Pennak, 1953).

Planorbidae: *Helisoma anceps* was found in 60% of the 25 lentic waters sampled and in 33% of the 124 lotic habitats. Harman (1968) found this species to be common in shallow, protected eutrophic ponds, but also in the quiet pools of small rivers and streams. *Helisoma trivolvis* was 11% more common in lentic waters than in lotic. Baker (1928) reports finding *trivolvis* frequently in quiet, more or less stagnant waters. *Helisoma campanulatum* was found to be an inhabitant of both lotic and lentic waters. This species was about 1% more common in lentic waters than in lotic waters. This percentage difference is small and probably inconsequential. Harman (1968) found *Helisoma campanulatum* to be present in lentic environments of usually small lakes in central New York state. Baker (1928) found this species also to be a common inhabitant of lakes. In this study, *Helisoma campanulatum*, was collected at eleven sites which were all lakes.

Helisoma truncatum was collected in this study from only the Carp River at three different locations. Baker (1928) describes H. truncatum as a species in rough waters of lakes in Wisconsin, and never found in stagnant bodies of water.

Gyraulus, and Promenetus are most often collected in vegetation choked lakes, ponds, and streams(Baker, 1928; Harman, 1968). Gyraulus parvus was encountered in 21% of the 124 lotic waters sampled and in 8% of the 25 lentic habitats during this study. It was frequently found attached to aquatic plants such as pondweeds(Potamogeton spp.), stonewort (Chara sp.), and yellow pond lilies(Nuphar advena). Gyraulus deflectus was 6% more frequent in lentic waters than in lotic, and Gyraulus hirsutus was collected only from lotic waters. Although only 33 specimens of G. hirsutus were collected during this study, it is not to be inferred that this species is absent from lentic habitats. In Wisconsin, Gyraulus deflectus is a species of quiet bodies of water, and Gyraulus hirsutus generally an inhabitant of eutrophic waters(Baker, 1928).

Promenetus exacuous in this study was collected only in lotic waters, but in protected areas. Baker(1928) found this species in Wisconsin generally in quiet places, more or less marshy. Since P. exacuous was collected from only three sites in this study, its distribution in lotic or lentic waters of Marquette County is difficult to determine.

Individuals of the family Planorbidae have developed a lobe(or lobes) of tissue that lies outside the mantle cavity and serves as a gill(pseudobranch). Harman(1968) has stated that this advanced modification gives them complete independence from atmospheric air. Few members of the family are ever found completely out of the water, but they do remain close to the surface in their usual habitats and breathing at the surface is common(Harman, 1968). The Planorbids are commonly found in most types of aquatic habitats(Harman, 1968; Hyman, 1967; Baker, 1928).

Physidae: The members of the family Physidae collected during this study were found to inhabit both lotic and lentic waters. *Physa gyrina* was 6% more common in lotic waters than in lentic. Baker(1928) found this species to be a common inhabitant of lakes, ponds, swamps, rivers, streams, and wood pools in Wisconsin. *Physa ancillaria* was 5% more common in lentic waters than in lotic, and *Physa integra* was collected only from lotic waters. Baker(1928) reports finding *P. integra* in practically all aquatic habitat types in Wisconsin. *Physa ancillaria* has also been found in a wide variety of habitats in Wisconsin(Baker, 1928). *Aplexa hyponorum* was collected only from the sluggish part of Morgan Creek in Marquette County. In Michigan and Wisconsin, this species is an inhabitant of ditches, swamps, and stagnant pools(Baker, 1928; Goodrich, 1932).

The mantle cavities of the Physids are similar to those of the Lymnaeids. In addition, the Physids have developed digitate outgrowths of the shell(Baker, 1928; Harman, 1968). It is thought that these outgrowths increase surface to volume relationships of the snail that result, theoretically at least, in less dependence on atmospheric air(Harman, 1968). However, Harman(1968) has cited W. R. Hunter for showing that there are no significant differences between the respiratory abilities of the Physidae or of the Lymnaeidae. The Physids together with the Lymnaeids commonly breathe at the surface of the water.

Ancylidae: In the present study, all the limpets of the genus *Ferrissia* were found in lotic waters-generally fast flowing rivers and creeks. Limpets have also been found in eutrophic Wisconsin lakes and ponds attached to aquatic plants such as bulrush(*Scirpus sp.*), and white pond lilies(*Nymphaea sp.*) (Baker, 1928). The family is represented by the freshwater limpets which commonly inhabit a patelloid shell and this is evidently an adaptation which has improved attachment and streamlining for life in flowing water or wave-beaten rocks. The freshwater limpets have pseudobranchs much like those of planorbid snails.

In summary, the Prosobranchs which must utilize their gills in respiration tend to be limited more to waters of higher oxygen content. The Pulmonates do not have gills but a mantle cavity that has developed into a "lung" and therefore are commonly found in all types of habitats including stagnant ditches, ponds, and swamps. In the present study, the prosobranchs were primarily collected in waters, which seemingly had a high oxygen content. The pulmonates collected were frequently found in such waters, but were also common in stagnant waters where there is generally a low amount of dissolved oxygen. The Pulmonates generally have a lighter shell per unit volume than Prosobranchs and are able to move quicker over vegetation substrate and surface films (Harman, 1968). Because pulmonates are better able to utilize air, they can tolerate more desiccation than most prosobranchs. These factors combined tend to result in higher dispersal rates for the pulmonates than for prosobranchs (Harman, 1968).

Water Temperature:

Table 4 shows the water temperature range and means found for twenty species of aquatic snails. The temperature ranges listed are based on temperatures taken at the time of collection. Since the waters visited during this study would undoubtedly reach higher and lower temperatures than indicated, it should not be assumed that these ranges are fixed. Figure 15, page 80, shows the average number of species

Table 4. Water Temperature Range and Mean(^{o} C) for Twenty Species of Snails.

Number of Sites	Species	Temperature Range (^{o}C)	Mean Temperature(^{o}C)
8	*Campeloma decisum*	20.0-23.0	21.4
37	*Physa gyrina*	5.5-23.5	17.8
6	*Physa ancillaria*	20.0-21.0	20.7
56	*Helisoma anceps*	5.5-23.5	19.7
22	*Helisoma trivolvis*	5.5-22.0	19.5
3	*Helisoma truncatum*	12.5-20.0	15.2
11	*Helisoma campanulatum*	19.0-21.0	20.3
28	*Gyraulus parvus*	5.5-23.5	18.7
10	*Gyraulus deflectus*	16.0-23.5	20.4
11	*Gyraulus hirsutus*	12.5-22.0	19.7
3	*Gyraulus circumstriatus*	18.5-20.5	19.7
9	*Ferrissia parallela*	15.0-21.5	18.4
3	*Ferrissia tarda*	15.5-17.0	16.3
3	*Lymnaea obrussa*	14.5-20.5	16.8
3	*Promenetus exacuous*	20.5-21.0	20.6
11	*Valvata tricarinata*	18.0-20.5	19.5
4	*Valvata sincera*	15.5-20.0	18.5
50	*Amnicola limosa*	5.5-23.5	18.4
5	*Amnicola lustrica*	20.0-23.5	21.0
3	*Amnicola integra*	18.5-22.0	20.2

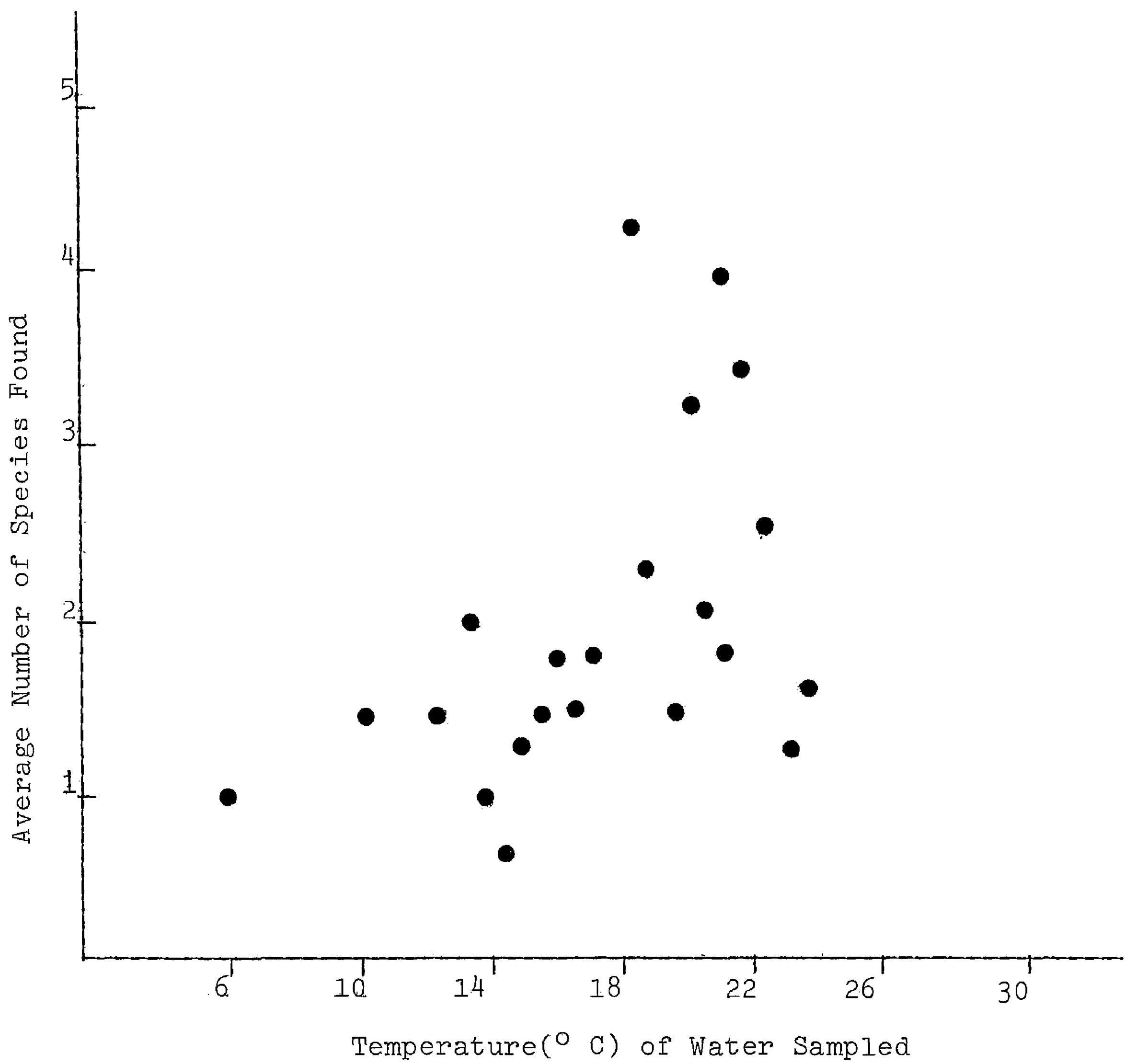


Figure 15. The Average Number of Species of Snails Found in Relation to Temperature of Water Sampled.

of snails found in relation to the temperature of the waters sampled. The data show that more species were collected in waters ranging from 18° C to 22° C than in cooler waters (6° C to 18° C). This probably means that the snails collected in this study thrive more in warmer water (18° C - 22° C) and are more available for collecting.

Freshwater snails are rather sensitive to warm temperatures and most cannot endure continuous exposure to temperatures above 30° C (Hyman, 1967). There tends to be a greater resistance to cold and freezing. Freshwater snails can withstand for some time being frozen in ice and may continue to be active under ice (Boycott, 1936; McNeil, 1963). Some lake pulmonates exhibit seasonal migrations correlated with temperature. In the fall they move into deeper waters and in the spring they migrate back to the shallower water (Cheatum, 1934; Pennak, 1953).

Temperature also appears to be of importance in the life of freshwater snails controlling the rate of development and reproduction (Van der Schalie and Berry, 1973). Some lymnaeids for example have been found to grow best at about 18° C with egg production better, but viability reduced at 22° C and above (Van der Schalie and Berry, 1973).

In the present study, Lymnaea obrussa was found at three collecting stations and was not present in waters above 20.5° C. The mean water temperature for this species was 16.8° C.

Lymnaea obrussa was encountered in fast flowing waters and it is probable that this species may therefore prefer cooler waters.

The Planorbid snails, of the genera *Physa*, *Helisoma*, *Promenetus*, and *Gyraulus* appear to tolerate warmer waters. *Helisoma trivolvis* is more tolerant of heat and pollution, so it is not uncommon to find it in areas where heat and eutrophication may have eliminated lymnaeid snails (Van der Schalie and Berry, 1973). In their EPA study on the effects of temperature on the growth and reproduction of snails, Van der Schalie and Berry found that *Helisoma trivolvis* grows best at higher temperatures (24° - 30° C) and that it does rather poorly at low temperatures. In the present study, the water temperature range for *Helisoma trivolvis* was between 5.5° C and 22.0° C, with a mean temperature of 19.5° C. *Helisoma anceps* also seems to be tolerant of warm temperatures. The water temperature range for this species is between 5.5° C and 23.5° C. The mean temperature for *Helisoma anceps* was 19.7° C. Both *H. trivolvis* and *H. anceps* were collected in a few waters in which the temperature was 5.5° C. It is probable then that these two species are present in waters ranging from 0° C to 5.5° C. Van der Schalie and Berry (1973) found *H. anceps* to develop best in cultures around 24° C, and to tolerate cooler water better than warm (approaching 30° C) water.

The Physid snails are often abundant in polluted waters and can maintain themselves in a much wider temperature range(12^{o}-30^{o} C)(Van der Schalie, 1973). The Physids wide tolerance to heat fluctuations may explain their distribution and dominance under adverse conditions(Van der Schalie, 1973). Physa gyrina in the present study had a water temperature range of 5.5^{o} C to 23.5^{o} C. This species is probably present in waters that range from 0^{o} C to 5.5^{o} C.

Experiments conducted by Van der Schalie and Berry (1973) indicate that the small amnicolid snails survive better in cold water and that they do not tolerate the temperatures 30^{o} C or higher. It was also shown that the optimum temperature for egg-laying by Amnicola limosa was about 18^{o}C (Van der Schalie and Berry, 1973). In the present study, Amnicola limosa was collected from fifty sites with a water temperature range of 5.5^{o} C to 23.5^{o} C and a mean temperature value of 18.4^{o} C.

Water Color:

Since no quantitative measurements were made of color, only a few comments can be made on the basis of gross observations.

In most of the sites visited during this study, the waters were clear. Members of the freshwater limpet family Ancylidae seem to prefer running waters where the water is clear.

Many of the planorbid snails, such as *Helisoma trivolvis*, *Physa gyrina*, and *Gyraulus parvus* were found in brownish waters with high amounts of dissolved organic matter. *Helisoma trivolvis* was encountered a few times in reddish-brown waters containing much organic matter and some iron. *Valvata tricarinata*, *Helisoma trivolvis*, *Gyraulus parvus*, and *Amnicola integra* were all found in water containing an extensive blue-green algal bloom at Deer Lake, Marquette County. Boycott(1936) has suggested that water color may play a minor role in determining the abundance and distribution of aquatic snails. It seems possible that some prosobranchs which tend to prefer clean water may be limited by water color-if this indicates a high amount of dissolved organic matter or silt in the water. Pulmonates, on the other hand are common in stagnant bodies of water where there is much dissolved organic matter. Water color probably would not be a limiting factor for Pulmonates.

Water Depth:

Most collecting done during this study was at depths ranging from 0.13 meters to 1.8 meters. Pennak(1953) states that the great majority of freshwater snails occur in shallow water, especially in water less than three meters deep. The fact that shallower regions are a favorite habitat for snails is probably correlated with the abundance of food in this zone. Some freshwater limpets have been found in lakes to a depth of 2,300 feet(Boycott, 1936). In this study, Somatogyrus subglobosus was found at a depth of 0.91 meters. Specimens have been taken from a depth of 15 feet in LaPlaisance Bay, Lake Erie by Berry(1943). Baker(1928) also collected S. subglobosus in fairly deep water of inland lakes in Wisconsin. The deepest water in which snails were collected from during this study, was at a depth of 1.2 meters to 1.8 meters in the Chocolay River(T46N-R24W-S1). Several immatures of the genera Lymnaea and Physa were taken from that collecting site. Lymnaea has been collected at a depth of 250 meters in Lake Geneva, Switzerland(Pennak, 1953). It has been determined that pulmonates occurring at great depths and some that remain submerged for long periods of time fill the pulmonary cavity with water and use it as a gill(Cheatum,1934).

Bottom Composition:

Appendix Table A6, pages 163-170 shows the bottom clas-sification of the waters studied , and the number of times each of twenty-nine species of aquatic snails occurred along these bottoms. Such variables as differences in the amount of time spent at each collecting site, and the few sites rep-resenting certain bottoms made it difficult to accurately de-scribe a particular bottom, and therefore to draw any statis-tical conclusion regarding the relationship of aquatic snails to bottom types. Because of this problem, only general con-clusions or comments can be made.

Table 5 shows the number of aquatic snails collected on various bottom types. The data indicates that most species of aquatic snails were found on a variety of bottom types. However, the greatest number of individuals were found on mucky bottoms with some detritus. Three species, namely, *Aplexa hyponorum*, *Valvata sincera*, and *Gyraulus altissimus* were found on mucky bottoms usually with some detritus. Pen-nak(1953) mentions that the Viviparidae are most common on sandy bottoms. In this study, *Viviparus georgianus* occurred in shallow water, on a sand, graveled bottom in Little Shag Lake. Hyman(1967) describes this species as being distribu-ted in lakes and streams in the bottom mud where it scavenges for food. Baker(1928) reports that *Viviparus georgianus* has been found in Wisconsin lakes and rivers on a mud bottom in

Table 5. The Number of Aquatic Snails Collected on Various Bottom Types.

Bottom Type	Number of Bottoms Sampled	Number of Species	Number of Individuals
Sand	1	2	5
Sand, Gravel	3	5	8
Sand, Gravel, Detritus	8	12	139
Sand, Bedrock	1	0	0
Sand, Rubble	14	14	120
Sand, Rubble, Detritus	21	10	155
Sand, Rubble, Boulders	3	4	6
Sand, Rubble, Boulders, and Detritus	2	1	5
Sand, Detritus	19	15	263
Fibrous Peat, Muck, and Detritus	2	1	3
Pulpy Peat, Muck	1	2	2
Pulpy Peat, Muck, and Detritus	4	5	31
Muck	10	7	170
Muck, Sand	5	11	170
Muck, Sand, Rubble, and Detritus		8	70
Muck, Sand, Boulders, and Detritus	1	0	0
Muck, Sand, Detritus	16	14	364
Muck, Rubble, Detritus	3	5	16
Muck, Detritus	30	17	477

shallow water, but in Oneida Lake, New York, *V. georgianus* was collected on a sand bottom as well as on a mud bottom. It seems apparent that this particular species can be found on both sand and mud bottoms.

Physa occurs in greatest abundance where there is a moderate amount of aquatic vegetation and organic debris, and it is uncommon among dense mats of vegetation(Pennak, 1953). In intermittent streams and ponds that are dry for a short period in the summer, many pulmonates burrow into the mud up to a depth of several inches and aestivate during the unfavorable period(Hyman, 1967). The most effective seal and protection is afforded by a mud and clay bottom. Some pulmonates form an epiphragm, a thin sheet of mucous which is formed just within the aperture by the foot(Cheatum, 1934). Upon drying, the epiphragm hardens and forms an effective seal which helps to prevent evaporation of moisture from the body. This epiphragm is usually produced when the snail is imbedded in mud(Pennak, 1953). In this study, *Physa gyrina* was found on all types of bottom, but most commonly in muddy bottoms with some detritus and sand. *Physa ancillaria* and *Physa integra* were also found on muddy bottoms, with some detritus and sand.

Helisoma and *Gyraulus* occurred more frequently in muck bottoms than in any other bottom type with a few exceptions. *Helisoma truncatum* occurred twice on a sandy bottom with some detritus. Baker(1928) never found this species in stagnant bodies of water in Wisconsin, but usually on sandy or rocky bottoms.

Promenetus exacuous was found to occur about the same on mud and sand bottoms. This species was found in beds of waterweed(*Anacharis sp.*), bladderwort(*Utricularia sp.*), stonewort(*Chara sp.*), and on some yellow water lilies(*Nuphar advena*). It was also present in Mountain Lake, Marquette County, on a bottom composed of muck and detritus.In central New York state, Harman(1968) found this species on floating, partially decayed logs, and also on the underside of decaying leaves of *Typha*, that floated on the surface of the water.

In the present study, *Campeloma decisum* occurred about twice as frequently on sandy bottoms than on mucky bottoms. Baker(1928) found this species to be common on a sandy bottom in rivers and creeks of Wisconsin. Harman(1968) reports this species as occurring in quiet bodies of water in central New York state, where the substrate is soft and the snail can burrow beneath the water-substrate interface.

Only two specimens of *Somatogyrus subglobosus* were collected in this study, and these were found on a sandy bottom with rubble. Baker(1928) reports this species occurring commonly on both sand and mud bottoms in Wisconsin. In this study, *Gyraulus parvus* occurred frequently on sandy bottoms and on mucky bottoms. This species in Wisconsin and Michigan is often found where there is an abundance of weeds, stones, sticks, and vegetation on sand and mud bottoms of lakes, rivers, ponds, and creeks(Baker, 1928; Goodrich, 1932). Gyraulus altissimus was found in Witch and Charleys Lakes on mucky bottoms covered with marl deposits. Baker(1928) reports that this species is apparently an extinct form known only from freshwater marl deposits.

The Lymnaeids collected during this study were found on both sandy and mucky bottoms. Pennak(1953) states that Lymnaeids occur in a wide variety of habitats, whereas many other genera appear to be restricted to particular types of substrates.

In summary, the problem of assigning a particular snail species to a bottom type is indeed difficult. The prosobranchs, which have gills that can be easily clogged by muddy waters, seem to prefer sandy bottoms, but did occur occasionally on silty, muddy bottoms. The pulmonates, which have developed lungs and are thereby more tolerant of mucky waters, were commonly found on bottoms composed of much dissolved organic matter. Most of the freshwater limpets(Ancylidae) have become adapted to living on hard, silt-free substrates, but have also been found attached to aquatic plants. The Amnicolids are usually found on substrates that can support thick beds of vegetation. Pianka(1966) has stated that a complex environment supports a more diverse fauna than a homogeneous environment. Ponds, ditches, and other small aquatic habitats tend to have only a few substrate types, whereas lakes and rivers contain many substrate types-a result of many factors, but primarily of water motion(Harman, 1968). Aquatic gastropods commonly prefer particular types of substrates(Harman, 1968). The diversity of some aquatic snail species, in an aquatic environment, may be determined by the diversity of substrates in that environment.

Biological Factors

Feeding Habits: The range of food eaten is wide and the variety of feeding mechanisms employed by gastropods are many (Barnes, 1968; Purchon, 1968). The Gastropoda includes micro-feeders utilizing brushing, scraping and filtering mechanisms; macrofeeders ranging from herbivores to predaceous carnivores, and fluid feeders which suck out the contents of algal cells (Owen, 1966). Many prosobranchs and most pulmonates are herbivores which feed on vegetation(Barnes, 1968). All but a few gastropods, have a radula, which is a highly developed feeding organ, consisting of many teeth arranged in rows(Barnes, 1968; Hyman, 1967; Pennak, 1953). The character and form of the radular teeth are relatively constant and considered important in the systematics of snails(Barnes, 1968). In general, the radula of herbivores consists of a large number of teeth, and the upper margin of the buccal cavity frequently bears one or more chitinous jaws used in cutting off bites of food(Pennak, 1953; Barnes, 1968). Some pulmonates and prosobranchs are carnivorous gastropods, which have a radula that usually contains much larger but fewer teeth, and jaws may also be present(Barnes, 1968).

Prosobranchs

Most of the members of the family Viviparidae are omnivorous, eating vegetation, detritus, decaying flesh and fecal material. They are found most abundantly in nutrient rich waters, but also inhabit oligotrophic lakes(Harman, 1968). *Viviparus georgianus* is typically a scavenger feeding on the substrate in the bottom mud of lakes, ponds, and streams (Hyman, 1967). Ciliary feeding also occurs in the genus *Viviparus* enabling these snails to feed without the energy loss that other species experience while moving or grazing in search of food(Harman, 1968; Purchon, 1968). With this type of feeding they are better hidden from predators by remaining in stationary position(Harman, 1968). According to Harman(1968), *Campeloma decisum* has been found to eat any animal or vegetable material it comes into contact with, and can be collected by baiting an area with dead organisms or fecal material. During this study, *Campeloma decisum* was collected in quiet waters where there was detritus or organic material present on the bottom.

The prosobranchs belonging to the family Valvatidae typically are found on aquatic plants in shallow areas and have been known to graze on gravel, sand, or silty substrates in deep water(Harman, 1968). In this study, *Valvata tricarinata* was commonly found on sandy or mud bottoms where there was grass, pondweeds(*Potamogeton spp.*), or waterweeds(*Anacharis sp.*). These snails seem to tolerate fine substrates because of the external gills which allow for good circulation for respiration without clogging of the mantle cavity(Harman, 1968).

The amnicolids are usually found in lentic or lotic waters that contain quantities of aquatic plants. In this study, Amnicola limosa was often abundant in waters containing thick beds of pondweeds(Potamogeton spp.), waterweed (Anacharis sp.), and stonewort(Chara sp.). These plants are not normally used as food by Amnicola limosa, but they do harbor diatoms which are eaten(Berry, 1943). Amnicola lustrica was collected at sites where Amnicola limosa was present. These two species often associate with each other(Berry, 1943).

Pulmonates

The freshwater pulmonates when gliding under the surface film, may eat small food particles it may contain, but they also eat submerged vegetation and scrape material from rocks and other surfaces(Hyman, 1967). All species of Physa were commonly found on all types of bottoms, especially on bottoms containing organic material and detritus. Physa gyrina appears to eat any material, animal or vegetable(Harman, 1968). The Physids collected during this study were often found in thick vegetation(Potamogeton spp., and Anacharis sp.), on the surface film of the water, and on partially submerged logs. The majority of the Lymnaeids collected during this study were found in waters where they were often seen grazing on the surface film of the water, or searching over an organic substrate.

The Planorbids were found in all types of habitats and the members of the genus *Helisoma* were commonly seen grazing on silty inorganic substrates in ponds, lakes and streams. Aquatic snails belonging to the genera *Gyraulus* and *Promenetus* were often collected on bottoms containing grasses(Gramineae), in thick beds of *Potamogeton spp.*, and also on yellow water lilies(*Nuphar advena*). The freshwater limpets of the genus *Ferrissia* were found to inhabit rock surfaces in flowing waters. These limpets feed by scraping the plant growth, especially algae, off rock surfaces.

Predators and Parasites of Aquatic Snails:

Predators: Predators may to a slight extent limit numbers of snails in a few isolated habitats. For example, the large planorbid snails of the genera *Helisoma* and *Lymnaea* may be reduced in a small pond if ducks or other birds are present, whereas other species of smaller snails may remain fairly common. In most situations, predators utilize practically all abundant species, and therefore have little influence on species diversity(Harman, 1968).Pulmonates and prosobranchs are eaten by fish, salamanders, frogs, toads, snakes, birds, and small mammals(hyman, 1967). Among the invertebrates, leeches(*Glossiphonia* *spp*. and *Helobdella* *spp*.), beetle(Coleoptera) larvae, and Hemiptera and Odonata nymphs are the most important predators of aquatic snails(Pennak, 1953; Kopenski, 1969). Insects, especially those belonging to the orders Coleoptera and Diptera, are among the serious predators of pulmonate snails. The water beetle *Dytiscus* *marginalis* has been said to kill the aquatic snail, *Lymnaea* *stagnalis*(Hyman, 1967). A rotifer, *Proales* *gigantea* is known to attack the egg masses of *Lymnaea* and *Physa*(Hyman, 1967).

Parasites: Many species of snails are known to serve as the intermediate hosts of trematodes. It is generally thought that such infections are seldom fatal to the snail, although its reproductive capacity may be greatly decreased(Pennak, 1953).

Many species belonging to the family Lymnaeidae are hosts to the larval stages of liver flukes *Fasciola hepatica* and *Fasciola gigantica*, whereas planorbids are hosts to the intestinal fluke *Fasciolopsis buski*(Hyman, 1967). *Physa gyrina* from Michigan is the snail host of the diplostomids *Fibricola cratera*, which infect raccoons(*Procyon lotor*) and opossums(*Didelphis marsupialis*)(Malek, 1962). Few trematodes infect ancylid snails. However, *Ferrissia parallela* has been found infected with the plagiorchid *Haematoloechus sp*.(Malek, 1962). Leeches of the non-blood sucking genus *Glossiphonia* are commensal in the mantle cavity of *Viviparus*(Hyman, 1967). Sporozoan parasites include a microsporidian *Plistophora husseyi* in Physidae, and ciliates are mostly commensals or parasites on many freshwater gastropods(Hyman, 1967).

Conclusions

1. Twenty-nine species of aquatic snails were taken from 149 waters in Marquette County, Michigan. All of these snails had been previously reported from the state.
2. *Viviparus georgianus*, *Somatogyrus subglobosus*, *Lymnaea columella*, *Lymnaea exilis*, *Gyraulus circumstriatus*, and *Helisoma truncatum* were collected from Marquette County waters and are the first records from the Upper Peninsula. *Aplexa hyponorum*, *Amnicola integra*, *Lymnaea megasoma*, and *Gyraulus umbilicatellus* had been previously reported from the Upper Peninsula, but were uncommon in Marquette County waters. The majority of the snails collected in this study have also been found in Wisconsin, Indiana, Illinois, Ohio, and Minnesota.
3. *Amnicola limosa* was the most abundant aquatic snail found during this study, while *Helisoma anceps* was the most frequently encountered species.
4. Ten of the aquatic snails found were widely distributed in Marquette County.
5. The abundance and distribution of the aquatic snails studied appeared to be restricted by waters with low pH. Nine of the waters sampled had a pH below 6.5. *Physa gyrina*, *Helisoma trivolvis*, *Helisoma campanulatum*, *Helisoma anceps*, *Valvata sincera*, *Amnicola limosa*, and *Gyraulus hirsutus*

were found in waters with the pH below 6.5; however they were not abundant in these waters. The waters with pH readings as high as 8.0 have no apparent effect on either the abundance or distribution of aquatic snails.

6. Oxygen content of water appears to have a direct effect on limiting some of the aquatic snails studied to certain types of habitats. The prosobranchs tend to be limited to waters of high oxygen content, and are therefore restricted mainly to lakes, rivers, and streams. The pulmonates are more tolerant of stagnant bodies of water such as ditches, ponds, and swamps. The freshwater limpets of the family Ancylidae were collected only from lotic waters and therefore appear to be restricted mainly to high oxygenated, fast-flowing waters.
7. Some lymnaeids are known to prefer cooler waters, but because few specimens of *Lymnaea* were collected in this study such an assumption cannot be verified or refuted. All other aquatic snails frequently encountered were found over a wide range of temperatures and seemed to be unaffected by warm temperatures.
8. The aquatic snails studied were most commonly found at depths ranging from 0.13-1.8 meters. They are most likely found at greater depths, but are probably restricted by a lack of available food in the deeper waters.

9. Most of the aquatic snails studied were found along a variety of bottom types. It seems that most species, particularly the pulmonates living in shallow water prefer a mucky bottom so that during periods of aestivation and hibernation,they can easily burrow into the substrate.

10. The feeding habits of gastropods as a group are many and probably exert some effect on their distribution and abundance. Many prosobranchs and most pulmonates are herbivorous feeders and therefore are generally found associated with vegetation. Other species, such as *Campeloma decisum* and *Viviparus georgianus* are typically scavengers and will feed on any kind of food material available to them.

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Appendix

Table A1. A Taxomonic Classification of Fresh water Gastropods (Morton and Yonge, 1964).

Phylum:	Mollusca	
Class:	Gastropoda	
Subclass:	Prosobranchiata	Pulmonata
Order:	Mesogastropoda	Basommatophora
Family:	Valvatidae	Ancylidae
	Amnicolidae	Planorbidae
	Viviparidae	Lymnaeidae
	Pleuroceridae	Physidae

Table A2. Floral Inhabitants of the Waters Studied in Marquette County

Station	*Nymphaea* sp.	*Nuphar* sp.	*Equisetum* sp.	*Elodea* sp.	*Potamogeton* sp.	*Myriophyllum* sp.	*Utricularia* sp.	*Typha* sp.	*Myrica gale*	*Vallisneria* sp.	*Sparganium* sp.	*Nasturtium* sp.	*Salix* sp.	*Nitella* sp.	*Chara* sp.	*Sphagnum* sp.	*Gramineae*	*Cyperaceae*
1																		
2		X		X	X													
3			X															
4		X			X	X												
5		X			X													
6		X		X	X													
7						X												
8		X	X															
9																	X	
10																	X	
11																	X	
12					X	X												

Table A2. Floral Inhabitants of the Waters Studied in Marquette County

Station	*Nymphaea* *sp.*	*Nuphar* *sp.*	*Equisetum* *sp.*	*Elodea* *sp.*	*Potamogeton* *sp.*	*Myriophyllum* *sp.*	*Utricularia* *sp.*	*Typha* *sp.*	*Myrica* *gale*	*Vallisneria* *sp.*	*Sparganium* *sp.*	*Nasturtium* *sp.*	*Salix* *sp.*	*Nitella* *sp.*	*Chara* *sp.*	*Sphagnum* *sp.*	*Gramineae*	*Cyperaceae*
13		X															X	X
14		X														X		
15																	X	
16		X							X						X			
17		X							X						X	X	X	
18																		
19																		
20																	X	
21																	X	
22																	X	
23																		
24																	X	
25																		X
26																		X

Table A2. Floral Inhabitants of the Waters Studied in Marquette County

Station	*Nymphaea* sp.	*Nuphar* sp.	*Equisetum* sp.	*Elodea* sp.	*Potamogeton* sp.	*Myriophyllum* sp.	*Utricularia* sp.	*Typha* sp.	*Myrica gale*	*Vallisneria* sp.	*Sparganium* sp.	*Nasturtium* sp.	*Salix* sp.	*Nitella* sp.	*Chara* sp.	*Sphagnum* sp.	*Gramineae*	*Cyperaceae*
27																		
28																	X	
29																	X	
30																		
31									X								X	
32									X								X	
33																	X	
34					X				X									X
35						X			X								X	X
36						X	X										X	
37								X										X
38				X	X													
39																		

Table A2. Floral Inhabitants of the Waters Studied in Marquette County

Station \ Flora	*Nymphaea* sp.	*Nuphar* sp.	*Equisetum* sp.	*Elodea* sp.	*Potamogeton* sp.	*Myriophyllum* sp.	*Utricularia* sp.	*Typha* sp.	*Myrica gale*	*Vallisneria* sp.	*Sparganium* sp.	*Nasturtium* sp.	*Salix* sp.	*Nitella* sp.	*Chara* sp.	*Sphagnum* sp.	*Gramineae*	*Cyperaceae*
40									X							X		
41																		
42																	X	
43																	X	
44																	X	
45				X	X												X	
46				X														
47																	X	
48																	X	
49																	X	
50																	X	
51																	X	

Table A2. Floral Inhabitants of the Waters Studied in Marquette County

Station	*Nymphaea* sp.	*Nuphar* sp.	*Equisetum* sp.	*Elodea* sp.	*Potamogeton* sp.	*Myriophyllum* sp.	*Utricularia* sp.	*Typha* sp.	*Myrica gale*	*Vallisneria* sp.	*Sparganium* sp.	*Nasturtium* sp.	*Salix* sp.	*Nitella* sp.	*Chara* sp.	*Sphagnum* sp.	*Gramineae*	*Cyperaceae*
52		X					X										X	
53		X															X	
54																	X	
55																	X	
56																	X	
57					X													
58				X														
59		X																
60		X			X													
61				X											X			
62															X		X	
63															X			X
64				X	X												X	
65					X												X	

Table A-2. Floral Inhabitants of the Waters Studied in Marquette County

Station \ Flora	*Nymphaea sp.*	*Nuphar sp.*	*Equisetum sp.*	*Elodea sp.*	*Potamogeton sp.*	*Myriophyllum sp.*	*Utricularia sp.*	*Typha sp.*	*Myrica gale*	*Vallisneria sp.*	*Sparganium sp.*	*Nasturtium sp.*	*Salix sp.*	*Nitella sp.*	*Chara sp.*	*Sphagnum sp.*	*Gramineae*	*Cyperaceae*
66					X												X	
67																	X	
68																	X	
69																	X	
70																	X	
71						X											X	
72							X										X	
73							X											
74																		
75																	X	
76																	X	
77																	X	
78																	X	
79																	X	

Table A2. Floral Inhabitants of the Waters Studied in Marquette County

Station \ Flora	*Nymphaea* *sp*.	*Nuphar* *sp*.	*Equisetum* *sp*.	*Elodea* *sp*.	*Potamogeton* *sp*.	*Myriophyllum* *sp*.	*Utricularia* *sp*.	*Typha* *sp*.	*Myrica* *gale*	*Vallisneria* *sp*.	*Sparganium* *sp*.	*Nasturtium* *sp*.	*Salix* *sp*.	*Nitella* *sp*.	*Chara* *sp*.	*Sphagnum* *sp*.	*Gramineae*	*Cyperaceae*
80																	X	
81																	X	
82			X															
83		X	X															X
84																	X	
85																		
86																		
87				X		X				X								
88					X	X			X									
89					X													
90				X	X	X												
91																	X	
92																	X	
93																	X	

Table A2. Floral Inhabitants of the Waters Studied in Marquette County

Station	*Nymphaea* *sp.*	*Nuphar* *sp.*	*Equisetum* *sp.*	*Elodea* *sp.*	*Potamogeton* *sp.*	*Myriophyllum* *sp.*	*Utricularia* *sp.*	*Typha* *sp.*	*Myrica* *gale*	*Vallisneria* *sp.*	*Sparganium* *sp.*	*Nasturtium* *sp.*	*Salix* *sp.*	*Nitella* *sp.*	*Chara* *sp.*	*Sphagnum* *sp.*	*Gramineae*	*Cyperaceae*
94																	X	
95																	X	
96																	X	
97																		
98																	X	
99								X	X								X	
100								X	X								X	
101					X												X	
102					X	X	X											
103																		
104																		
105																	X	
106																	X	

Table A2. Floral Inhabitants of the Waters Studied in Marquette County

Station \ Flora	*Nymphaea* *sp.*	*Nuphar* *sp.*	*Equisetum* *sp.*	*Elodea* *sp.*	*Potamogeton* *sp.*	*Myriophyllum* *sp.*	*Utricularia* *sp.*	*Typha* *sp.*	*Myrica* *gale*	*Vallisneria* *sp.*	*Sparganium* *sp.*	*Nasturtium* *sp.*	*Salix* *sp.*	*Nitella* *sp.*	*Chara* *sp.*	*Sphagnum* *sp.*	*Gramineae*	*Cyperaceae*
107																		
108																	X	
109				X	X												X	
110																	X	
111				X	X													
112		X																
113	X					X	X											
114																		
115									X								X	
116		X				X	X	X	X						X	X	X	X
117		X													X		X	
118																	X	
119																	X	
120																	X	

Table A2. Floral Inhabitants of the Waters Studied in Marquette County

Station	*Nymphaea* sp.	*Nuphar* sp.	*Equisetum* sp.	*Elodea* sp.	*Potamogeton* sp.	*Myriophyllum* sp.	*Utricularia* sp.	*Typha* sp.	*Myrica gale*	*Vallisneria* sp.	*Sparganium* sp.	*Nasturtium* sp.	*Salix* sp.	*Nitella* sp.	*Chara* sp.	*Sphagnum* sp.	*Gramineae*	*Cyperaceae*
121																	X	
122																	X	
123			X														X	
124			X														X	
125																	X	X
126		X							X								X	X
127		X							X							X	X	
128																	X	X
129																	X	
130																		
131																	X	
132																	X	
133																		
134																		

Table A2. Floral Inhabitants of the Waters Studied in Marquette County

Station \ Flora	*Nymphaea* *sp*.	*Nuphar* *sp*.	*Equisetum* *sp*.	*Elodea* *sp*.	*Potamogeton* *sp*.	*Myriophyllum* *sp*.	*Utricularia* *sp*.	*Typha* *sp*.	*Myrica* *gale*	*Vallisneria* *sp*.	*Sparganium* *sp*.	*Nasturtium* *sp*.	*Salix* *sp*.	*Nitella* *sp*.	*Chara* *sp*.	*Sphagnum* *sp*.	*Gramineae*	*Cyperaceae*
135						X											X	
136			X															
137				X														
138				X													X	
139				X													X	
140				X	X												X	
141																	X	
142																	X	
143				X														
144				X	X												X	
145					X												X	
146					X													
147																		
148																		
149																		

Table A3. Faunal Inhabitants of the Waters Studied in Marquette County.

STATION	Sphaeriidae	Unionidae	Crayfish	Frogs	Leeches	Amphipoda	Sponges	Cyprinidae	Centrarchidae	Ictaluridae	Percidae	Trichoptera	Coleoptera	Hemiptera	Odonata	Ephemeroptera	Chironomidae	Plecoptera	Gasterosteidae	Esocidae	Umbridae	Salmonidae	Cottidae
1			X				X								X								
2			X			X						X			X								
3	X											X											
4	X												X		X								
5	X												X		X								
6	X						X								X								
7			X			X									X								
8			X			X									X								
9														X									
10															X								

TABLE A3 (cont'd)

Fauna	STATION 11	12	13	14	15	16	17	18	19	20
Sphaeriidae	X	X				X			X	X
Unionidae					X					
Crayfish		X	X		X					
Frogs				X						
Leeches				X						
Amphipoda		X								
Sponges		X	X	X	X					
Cyprinidae				X						
Centrarchidae										
Ictaluridae										
Percidae										
Trichoptera										
Coleoptera										
Hemiptera								X		
Odonata	X	X	X		X	X	X			
Ephemeroptera		X								
Chironomidae		X								
Plecoptera										
Gasterosteidae										
Esocidae										
Umbridae										
Salmonidae										
Cottidae										

TABLE A3 (cont'd).

Fauna	STATION 21	22	23	24	25	26	27	28	29	30
Sphaeriidae				X	X				X	X
Unionidae										
Crayfish	X	X				X	X	X	X	
Frogs					X					
Leeches				X	X					
Amphipoda										
Sponges			X	X		X	X		X	X
Cyprinidae									X	
Centrarchidae										
Ictaluridae										
Percidae										
Trichoptera						X				
Coleoptera						X	X			
Hemiptera										
Odonata	X	X	X	X	X	X	X	X	X	
Ephemerotera									X	
Chironomidae										
Plecoptera										
Gasterosteidae										
Esocidae										
Umbridae										
Salmonidae										
Cottidae										

TABLE A3 (cont'd).

Fauna	STATION 31	32	33	34	35	36	37	38	39	40
Sphaeriidae								X	X	X
Unionidae										
Crayfish				X	X		X			
Frogs						X			X	
Leeches									X	X
Amphipoda			X						X	
Sponges			X						X	X
Cyprinidae										
Centrarchidae										
Ictaluridae										
Percidae										
Trichoptera										
Coleoptera										
Hemiptera										
Odonata		X	X	X	X	X	X	X	X	
Ephemeroptera	X							X		
Chironomidae										
Plecoptera										
Gasterosteidae										
Esocidae										
Umbridae										
Salmonidae										
Cottidae										

TABLE A3 (cont'd).

Fauna	STATION 41	42	43	44	45	46	47	48	49	50
Sphaeriidae										
Unionidae										
Crayfish			X	X						
Frogs										
Leeches					X					
Amphipoda						X				
Sponges	X						X			
Cyprinidae	X						X			
Centrarchidae										
Ictaluridae										
Percidae										
Trichoptera				X	X					
Coleoptera			X	X						
Hemiptera					X					
Odonata		X				X	X	X	X	X
Ephemerotera	X						X			
Chironomidae										
Plecoptera										
Gasterosteidae										
Esocidae										
Umbridae										
Salmonidae										
Cottidae										

TABLE A3(cont'd).

STATION \ Fauna	Sphaeriidae	Unionidae	Crayfish	Frogs	Leeches	Amphipoda	Sponges	Cyprinidae	Centrarchidae	Ictaluridae	Percidae	Trichoptera	Coleoptera	Hemiptera	Odonata	Ephemeroptera	Chironomidae	Plecoptera	Gasterosteidae	Esocidae	Umbridae	Salmonidae	Cottidae
51							X								X								
52						X	X								X								
53																							
54												X	X										
55	X		X				X								X	X							
56	X		X				X								X								
57	X														X								
58	X		X																				
59			X												X								
60															X								

TABLE A3 (cont'd).

Fauna	STATION 61	62	63	64	65	66	67	68	69	70
Sphaeriidae										
Unionidae										
Crayfish				X						
Frogs			X							
Leeches										
Amphipoda										
Sponges			X	X			X	X	X	
Cyprinidae			X	X	X					
Centrarchidae										
Ictaluridae										
Percidae										
Trichoptera										
Coleoptera										
Hemiptera										
Odonata	X	X		X	X	X	X	X	X	X
Ephemeroptera							X			
Chironomidae										
Plecoptera										
Gasterosteidae										
Esocidae										
Umbridae										
Salmonidae										
Cottidae										

TABLE A3(cont'd).

Fauna	STATION 71	72	73	74	75	76	77	78	79	80
Sphaeriidae			X							
Unionidae			X							
Crayfish				X						
Frogs										
Leeches		X								
Amphipoda	X									
Sponges			X	X			X	X	X	
Cyprinidae							X	X		
Centrarchidae										X
Ictaluridae										X
Percidae				X						X
Trichoptera			X			X	X	X		
Coleoptera				X						
Hemiptera										
Odonata	X	X	X	X	X	X	X	X	X	X
Ephemeroptera			X	X	X		X			
Chironomidae										
Plecoptera										
Gasterosteidae										
Esocidae										
Umbridae										
Salmonidae										
Cottidae										

TABLE A3 (cont'd)

Fauna	STATION 81	82	83	84	85	86	87	88	89	90
Sphaeriidae										
Unionidae										
Crayfish					X	X	X			
Frogs										X
Leeches										X
Amphipoda									X	
Sponges			X	X	X	X		X		X
Cyprinidae		X					X	X		
Centrarchidae										
Ictaluridae										
Percidae										
Trichoptera										
Coleoptera										
Hemiptera							X			
Odonata	X	X	X	X	X	X	X	X	X	X
Ephemeroptera	X				X	X			X	
Chironomidae						X				
Plecoptera										
Gasterosteidae										
Esocidae										
Umbridae										
Salmonidae										
Cottidae										

TABLE A3(cont'd).

Fauna	91	92	93	94	95	96	97	98	99	100
Sphaeriidae	X	X								
Unionidae										
Crayfish				X	X				X	X
Frogs						X	X			
Leeches						X		X		
Amphipoda										
Sponges					X			X	X	X
Cyprinidae						X	X			
Centrarchidae										
Ictaluridae										
Percidae						X	X			
Trichoptera				X						
Coleoptera			X	X	X			X	X	
Hemiptera										
Odonata	X	X	X		X	X		X	X	
Ephemeroptera		X								
Chironomidae										
Plecoptera										
Gasterosteidae										
Esocidae										
Umbridae										
Salmonidae										
Cottidae	X	X	X							

TABLE A3(cont'd).

Fauna	101	102	103	104	105	106	107	108	109	110
Sphaeriidae										
Unionidae										
Crayfish		X								
Frogs			X	X		X				
Leeches			X			X				
Amphipoda		X	X							
Sponges						X			X	
Cyprinidae						X				X
Centrarchidae										
Ictaluridae										
Percidae										
Trichoptera										
Coleoptera										
Hemiptera										
Odonata	X	X			X	X	X	X	X	X
Ephemeroptera	X					X		X	X	
Chironomidae										
Plecoptera										
Gasterosteidae										
Esocidae										
Umbridae										
Salmonidae										
Cottidae										

TABLE A3(cont'd)

Fauna	STATION 111	112	113	114	115	116	117	118	119	120
Sphaeriidae										
Unionidae										
Crayfish		X	X	X	X		X			
Frogs					X		X			
Leeches		X			X				X	
Amphipoda	X			X					X	
Sponges		X	X		X	X	X		X	
Cyprinidae									X	
Centrarchidae										X
Ictaluridae										
Percidae										
Trichoptera								X		
Coleoptera				X			X			
Hemiptera		X	X							
Odonata	X	X	X	X		X	X	X	X	X
Ephemeroptera				X						
Chironomidae										
Plecoptera										
Gasterosteidae										
Esocidae										
Umbridae										
Salmonidae				X	X					
Cottidae										

TABLE A3 (cont'd).

Fauna	STATION 121	122	123	124	125	126	127	128	129	130
Sphaeriidae									X	
Unionidae										X
Crayfish			X	X	X	X	X	X		X
Frogs										
Leeches										
Amphipoda										
Sponges	X	X			X	X	X			
Cyprinidae										
Centrarchidae										
Ictaluridae										
Percidae										
Trichoptera										
Coleoptera										
Hemiptera										
Odonata	X	X	X	X	X	X	X	X		
Ephemeroptera	X									
Chironomidae										
Plecoptera										
Gasterosteidae										
Esocidae										
Umbridae	X	X	X	X						
Salmonidae										
Cottidae										

TABLE A3(cont'd).

Fauna	131	132	133	134	135	136	137	138	139	140
Sphaeriidae										
Unionidae						X				
Crayfish	X	X			X					
Frogs										
Leeches		X							X	
Amphipoda		X							X	
Sponges	X	X	X	X	X			X		X
Cyprinidae										
Centrarchidae								X		
Ictaluridae								X		
Percidae								X		
Trichoptera	X	X								
Coleoptera										
Hemiptera										
Odonata		X	X	X	X				X	X
Ephemeroptera									X	
Chironomidae										
Plecoptera										
Gasterosteidae										
Esocidae										
Umbridae										
Salmonidae										
Cottidae										

TABLE A3(cont'd).

Fauna	141	142	143	144	145	146	147	148	149
Sphaeriidae									
Unionidae			X						
Crayfish			X						
Frogs									
Leeches									
Amphipoda									
Sponges					X	X	X		
Cyprinidae				X				X	
Centrarchidae									
Ictaluridae									
Percidae									
Trichoptera									
Coleoptera			X						
Hemiptera				X		X			
Odonata	X	X			X				
Ephemeroptera									
Chironomidae									
Plecoptera									
Gasterosteidae									
Esocidae									
Umbridae									
Salmonidae									
Cottidae									

Table A4. Physical Features of the Waters Investigated in Marquette County

Station	Date Collected	Bottom	Depth (Meters)	Color	Temp. °C	pH
	6-3-74	sandy, rubble, detritus	.61 m	clear	19.0	7.0
	6-3-74	sandy, gravel, detritus	.30 m	clear	20.5	7.3
	6-3-74	sandy, detritus	.30 m	clear	23.5	7.3
	6-3-74	muck, detritus	.15 m	clear	19.5	6.2
	6-3-74	sandy, some muck, detritus	.30 m	clear	19.0	6.5
	6-3-74	sandy, rubble, detritus	.30 m	clear	19.0	N.R.
	6-8-74	sandy, gravel, detritus	.46 m	clear	18.0	N.R.
	6-8-74	muck, detritus	.61 m	clear	18.0	N.R.
	6-8-74	muck, detritus	.30 m	clear - brown	19.0	7.1
10	6-8-74	sandy, some rubble, muck, detritus	.30 m	clear	20.0	7.2
11	7-12-74	sandy, gravel, detritus	.46-.91m	clear	19.0	N.R.
12	7-12-74	muck, detritus	.46 m	clear	23.0	6.8
13	7-13-74	detritus	.30 m	brown-clear	22.0	6.8
14	7-16-74	pulpy peat, detritus muck	.30 m	brownish	23.5	6.5
15	7-16-74	rubble, sandy	.46 m	clear	23.0	7.0

N.R. = No Reading

Table A4(cont'd.)

Station	Date Collected	Bottom	Depth (Meters)	Color	Temp. °C	pH
16	7-18-74	muck	.46 m	clear	22.0	N.R.
17	7-18-74	muck	.30 m	clear	21.0	N.R.
18	7-19-74	sandy,rubble	.46 m	clear	22.0	N.R.
19	7-19-74	rubble,sandy, detritus	.23 m	green (due to algal bloom)	20.0	7.2
20.	7-19-74	rubble,sandy, detritus	.61 m	clear	22.0	N.R.
21.	7-22-74	muck,tree stumps	.15 m	brown	20.0	6.8
22	7-22-74	muck	.15 m	brown		N.R.
23	7-23-74	muck,detritus	.15 m	clear	20.0	7.2
24	7-19-74	sandy,gravel	.46 m	clear	19.5	7.0
25	7-23-74	detritus,muck	.30 m	clear	16.0	7.2
26	7-23-74	sandy,detritus	.15 m	clear	16.0	7.2
27	7-23-74	rubble,detritus, mud	.30 m	brown	16.0	7.2
28	7-23-74	detritus,muck	.30 m	clear	21.0	7.3
29	7-23-74	sandy,rubble, detritus	.30 m	clear	17.0	7.3
30	7-23-74	sandy,muddy, detritus,rubble	.30 m	clear	21.5	7.4
31	7-23-74	sandy,rubble	.30-.91m	clear	21.0	7.3-7.4
32	7-23-74	sandy,rubble	.61 m	clear	20.0	7.0

Table A4(cont'd.)

Station	Date Collected	Bottom	Depth (Meters)	Color	Temp. °C	pH
33	7-21-74	sandy,detritus	.61 m	clear	20.0	7.0
34	7-24-74	sandy,detritus	.30 m	clear	21.0	7.3
35	7-24-74	sandy,detritus	.61 m	clear	20.5	7.1
36	7-24-74	muck,rubble detritus	.15 m	clear	21.0	7.1
37	7-24-74	pulpy peat, muck,detritus	.30 m	clear, brown,(algae)	21.0	7.0
38	7-25-74	sandy,mud, detritus	.61 m	clear	12.0	7.2
39	7-26-74	sandy,detritus	.61 m	clear	20.5	7.1
40	7-26-74	pulpy peat, detritus	.30 m	clear	21.0	7.1
41	7-26-74	sandy,detritus	.30-.91m	clear	21.0	7.1
42	7-26-74	sandy,detritus	.46 m	clear	21.0	7.1
43	7-26-74	fibrous peat, mud,detritus	.15 m	clear	21.0	7.1
44	7-26-74	rubble,sandy, detritus	.30 m	clear	15.5	7.3
45	7-26-74	sandy,detritus some muck	.61 m	clear	17.0	7.2
46	7-26-74	sandy,mucky, detritus	.61 m	clear	16.5	7.1
47	7-27-74	sandy,rubble, detritus	.61 m	clear	15.0	7.1
48	7-27-74	sandy,detritus	.15 m	clear	21.0	7.1
49	7-27-74	muck	.76 m	brown	16.5	6.8

Table A4(cont'd.)

Station	Date Collected	Bottom	Depth (Meters)	Color	Temp. °C	pH
50	7-27-74	sandy,detritus	.30 m	clear	18.5	6.5-6.8
51	7-27-74	sandy,some muck,detritus	.46 m	clear	20.0	6.9
52	7-27-74	sandy,some muck,detritus	.76 m	clear	20.0	7.1-7.2
53	7-27-74	sandy,detritus	.13 m	clear	20.0	7.0-7.1
54	7-27-74	rubble,boulders, sandy	.30 m	clear	18.5	7.2
55	7-28-74	sandy	.76 m	clear	18.5	7.1
56	7-28-74	mucky,detritus	.46 m	clear-brown	20.0	7.4
57	7-28-74	sandy,gravel detritus	.15-.46m	clear	19.5	7.4-7.5
58	7-28-74	sandy,gravel	.30-.91m	clear	20.5	7.5
59	7-30-74	mucky detritus	.46 m	clear	23.5	6.7
60	7-30-74	muck,detritus	.46 m	clear-brown	19.5	7.0
61	7-30-74	sandy,mud, detritus	.23 m	clear	20.0	7.1
62	7-31-74	sandy,rubble	.30 m	clear	15.5	7.0
63	7-31-74	sandy,gravel some detritus	.15 m	clear	17.0	7.0
64	7-31-74	sandy,rubble, detritus	.23 m	clear	17.0	7.2
65	7-31-74	sandy,boulders, rubble	.15 m	clear	15.5	7.1-7.2

Table A4(cont'd.)

Station	Date Collected	Bottom	Depth (Meters)	Color	Temp. °C	pH
66	8-2-74	sandy, detritus, muck	.30-.91m	clear	16.5	7.2
67	8-2-74	sandy, rubble	.30 m	clear	18.0	7.0
68	8-2-74	sandy, mud, boulders, bedrock, detritus	.46 m	clear	16.5	7.1
69	8-2-74	sandy, rubble	.30 m	clear	18.0	7.0
70	8-2-74	sandy, rubble detritus	.23 m	clear	16.0	7.1
71	8-2-74	muck, detritus pulpy peat	.30 m	clear	21.0	7.6
72	8-5-74	muck, pulpy peat	.30 m	reddish-brown	18.5	6.5-6.8
73	8-5-74	sandy, rubble	.91 m	clear	20.5	7.0
74	8-5-74	sandy, rubble detritus	.61 m	clear	16.5	6.9
75	8-5-74	muck	.46 m	clear	20.0	7.1
76	8-5-74	sandy, rubble, detritus	.30 m	clear	20.0	7.0
77	8-6-74	sandy, rubble, detritus	.46 m	clear	15.5	7.2
78	8-6-74	sandy, muddy, silty	.61 m	clear	18.5	7.2
79	8-6-74	muck, some sand	.30 m	clear	20.0	7.1
80	8-6-74	sandy, rubble, boulders	.30 m	clear	20.0	7.2
81	8-6-74	muck	.46 m	clear	20.5	7.0

Table A4(cont'd.)

Station	Date Collected	Bottom	Depth (Meters)	Color	Temp. °C	pH
82	8-6-74	sandy,rubble	.46 m	clear	18.5	7.2
83	8-6-74	muck,detritus	.30 m	clear	21.0	7.3
84	8-9-74	sandy,some mud	.46 m	clear	21.0	7.0
85	8-9-74	mud,detritus	.76 m	clear	20.0	7.3
86	8-9-74	solid rock (pothole) detritus mud	.12 m	clear	21.0	7.3
87	8-10-74	sandy,some muck	.91 m	clear	20.0	7.0
88	8-10-74	muck,detritus	.61 m	clear	21.0	6.9
89	8-10-74	sandy, some muck,detritus	.30 m	clear	20.0	7.3
90	8-10-74	muck,detritus	.61 m	clear	21.0	7.0
91	8-10-74	sandy,rubble	.30 m	clear	14.5	7.3
92	8-11-74	sandy,rubble some detritus	.30 m	clear	14.5	7.2
93	8-11-74	sandy,rubble detritus,some muck	1.2-1.8m	clear	15.0	7.3
94	8-11-74	sandy,rubble	.61-1.2m	clear	15.0	N.R.
95	8-12-74	sandy,gravel, some detritus	.15 m	clear	20.0	6.8-6.9
96	8-12-74	muck	.30 m	reddish brown	20.0	6.5
97	8-12-74	muck,detritus	.30 m	reddish brown	20.0	6.5

Table A4(cont'd.)

Station	Date Collected	Bottom	Depth (Meters)	Color	Temp. °C	pH
98	8-12-74	muck,detritus	.46 m	brown	20.0	6.3-6.5
99	8-12-74	muck,detritus	.61 m	reddish brown	21.0	6.4
100	8-12-74	bog-like detritus. fibrous peat,muck	61m	clear	20.0	6.3
101	8-12-74	sandy,rubble detritus	.30 m	clear	20.0	7.0
102	8-13-74	sandy,gravel detritus	.30-.91m	clear	20.0	7.2
103	8-13-74	tree stumps, muck,detritus	.46 m	brown	18.5	7.0-7.2
104	8-13-74	sandy muck, in some areas detritus	.30 m	clear	20.5	6.8
105	8-13-74	sandy,rubble muck,detritus	.46 m	clear	14.5	7.2-7.3
106	8-14-74	muck,detritus	.61 m	clear	21.0	6.8
107	8-14-74	sandy,rubble some muck,detritus	.61 m	clear	17.0	7.1-7.2
108	8-14-74	sandy,detritus	.84 m	clear	19.5	7.1-7.2
109	8-14-74	sandy,rubble detritus	.46 m	clear	15.5	6.6
110	8-16-74	sandy,detritus	.30 m	clear	21.0	7.2
111	8-16-74	sandy,rubble some muck, detritus	1.4 m	clear-reddish brown	20.5	7.2
112	8-19-74	muck,detritus	.46 m	clear	21.0	7.2
113	8-20-74	muck,some sand detritus	.61 m	clear	21.0	7.3-7.5

Table A4(cont'd.)

Station	Date Collected	Bottom	Depth (Meters)	Color	Temp. °C	pH
114	8-20-74	sandy,rubble detritus	.23 m	clear	19.0	7.2-7.4
115	8-20-74	muck,detritus	.23 m	clear-yellow	20.0	6.9
116	8-21-74	muck,detritus	.15 m	clear	21.0	7.1
117	8-21-74	muck	.46 m	clear-brown	21.0	7.4-7.6
118	8-21-74	sandy,rubble	.46 m	clear	16.5	7.4
119	8-21-74	sand,detritus	.46 m	clear	20.0	6.8
120	8-21-74	marl,muck	.23 m	clear	20.5	7.8-8.1
121	8-22-74	sandy,rubble detritus	.23 m	clear	16.0	7.4
122	8-22-74	muck,rubble detritus	.76 m	clear	19.5	7.4
123	8-22-74	muck,detritus	.46 m	clear-brown	20.0	7.3-7.5
124	8-22-74	sandy,rubble detritus	.15 m	brown		6.2
125	8-23-74	sandy,detritus	.15 m	clear	22.0	6.6
126	8-23-74	muck,detritus	.30-.76 m	clear	19.5	6.4
127	8-23-74	muck,detritus	.91 m	clear	18.5	7.2-7.5
128	8-24-74	sandy,rubble	.23 m	clear	23.5	6.5-6.8
129	8-24-74	sandy,rubble	.46 m	clear	23.5	6.3-6.8
130	8-24-74	sandy,gravel detritus	.46 m	clear	23.5	7.3

Table A4(cont'd.)

Station	Date Collected	Bottom	Depth (Meters)	Color	Temp. °C	pH
131	8-24-74	sand, detritus boulders, rubble	.30 m	clear	20.0	7.1
132	8-24-74	detritus, sandy some muck	.91 m	clear	21.0	7.1
133	8-24-74	detritus, sandy some muck	.15 m	clear	21.0	7.4
134	8-24-74	sandy, detritus	.61 m	clear	21.0	7.2
135	8-24-74	sandy, detritus	.61 m	clear	23.0	7.2
136	8-24-74	sandy, rubble, some detritus	.15 m	clear	21.5	7.2-7.1
137	8-20-74	sandy, rubble	.46 m	clear	21.0	7.2
138	8-10-74	sandy, gravel	.46 m	clear	20.0	7.0
139	6-6-74	muck, detritus	.46 m	clear	18.5	7.1
140	8-29-74	sandy, detritus, some muck	.76 m	clear	10.0	7.2
141	8-29-74	sandy, some muck	.76 m	clear	10.0	6.4
142	8-29-74	tree stumps, muck, detritus	.30 m	clear	15.5	6.4
143	9-7-74	sandy, detritus	.46 m	clear	13.0	N.R.
144	9-7-74	sandy, detritus	.46 m	clear	12.5	N.R.
145	10-5-74	sandy, rubble, some detritus	.61 m	clear	12.5	6.3
146	10-21-74	sandy, some muck, detritus	.46 m	clear	6.0	7.1

Table A4(cont'd.)

Station	Date Collected	Bottom	Depth (Meters)	Color	Temp. °C	pH
147	10-21-74	muck,detritus	.46 m	clear	5.5	7.2
148	10-21-74	mucky,detritus	.30 m	clear	5.5	N.R.
149	10-21-74	sandy, some muck,detritus	.61 m	clear	6.0	N.R.

Table A5. The Number of Aquatic Snails collected for each species in Marquette County, Michigan.

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
1	6-3-74																				1								1						
	6-3-74																					1	1		8									10	
	6-3-74																								52	2				16					
	6-3-74																																		
	6-3-74									40																									
	6-3-74																																		
	6-8-74																						9		14										

Table A5. (cont'd).

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megosoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
8	6-8-74			2				1		1											4		3		9				15						
	6-8-74																						1	1				1	1						
10	6-8-74																						34		11										
11	7-12-74																																		
12	7-12-74																													30					
13	7-13-74																																		
14	7-16-74																																		

Table A5. (cont'd).

Species	15	16	17	18	19	20	21
Date Collected	7-16-74	7-18-74	7-18-74	7-19-74	7-19-74	7-19-74	7-22-74
Campeloma decisum	2						
Viviparus georgianus							
Physa gyrina							17
Physa ancillaria							
Physa integra							
Physa sp.		13					
Helisoma trivolvis		2					
Helisoma campanulatum							
Helisoma anceps		1					
Helisoma truncatum							
Helisoma sp.							
Somatogyrus subglobosus							
Ferrissia parallela							
Ferrissia tarda							
Aplexa hyponorum							
Lymnaea obrussa							
Lymnaea columella							
Lymnaea megosoma							
Lymnaea exilis							
Lymnaea sp.							
Menetus exacuous							
Valvata tricarinata							
Valvata sincera							
Amnicola limosa						10	
Amnicola lustricá							
Amnicola integra					1		
Amnicola sp.							
Gyraulus parvus					5		
Gyraulus deflectus							
Gyraulus hirsutus							
Gyraulus umbilicatellus							
Gyraulus altissimus							
Gyraulus circumstriatus							
Gyraulus sp.							

Table A5. (cont'd)

Species	Station 22	Station 23	Station 24	Station 25	Station 26	Station 27	Station 28
Date Collected	7-22-74	7-23-74	7-19-74	7-23-74	7-23-74	7-23-74	7-23-74
Campeloma decisum							
Viviparus georgianus							
Physa gyrina				61			
Physa ancillaria							
Physa integra							
Physa sp.						13	17
Helisoma trivolvis							
Helisoma campanulatum		3					
Helisoma anceps	62						
Helisoma truncatum							
Helisoma sp.							
Somatogyrus subglobosus							
Ferrissia parallela							
Ferrissia tarda							
Aplexa hyponorum							
Lymnaea obrussa							
Lymnaea columella							
Lymnaea megasoma							
Lymnaea exilis							
Lymnaea sp.							
Menetus exacuous							
Valvata tricarinata							
Valvata sincera							
Amnicola limosa							
Amnicola lustrica							
Amnicola integra							
Amnicola sp.							
Gyraulus parvus							
Gyraulus deflectus							
Gyraulus hirsutus							
Gyraulus umbilicatellus							
Gyraulus altissimus							
Gyraulus circumstriatus							
Gyraulus sp.							

Table A5. (cont'd).

Species	29	30	31	32	33	34	35
Date Collected	7-23-74	7-23-74	7-23-74	7-23-74	7-21-74	7-24-74	7-24-74
Campeloma decisum							
Viviparus georgianus			9				
Physa gyrina							
Physa ancillaria			1				
Physa integra							
Physa sp.	38						15
Helisoma trivolvis							
Helisoma campanulatum							
Helisoma anceps							
Helisoma truncatum							
Helisoma sp.							
Somatogyrus subglobosus							
Ferrissia parallela	1						
Ferrissia tarda	2						
Aplexa hyponorum							
Lymnaea obrussa							
Lymnaea columella							
Lymnaea megasoma							
Lymnaea exilis							
Lymnaea sp.							
Menetus exacuous							
Valvata tricarinata							
Valvata sincera							
Amnicola limosa	3						
Amnicola lustrica							
Amnicola integra							
Amnicola sp.							
Gyraulus parvus							10
Gyraulus deflectus							
Gyraulus hirsutus							
Gyraulus umbilicatellus							
Gyraulus altissimus							
Gyraulus circumstriatus							
Gyraulus sp.							

Table A5. (cont'd).

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella
36	7-24-74						4	2										
37	7-24-74						17											
38	7-25-74						8											
39	7-26-74							4	4	7								
40	7-26-74																	
41	7-26-74																	
42	7-26-74																	

Station	Date Collected	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
36	7-24-74													2				
37	7-24-74																	
38	7-25-74																	
39	7-26-74					1		15										
40	7-26-74							2										
41	7-26-74																	
42	7-26-74																	

Table A5. (cont'd).

		Species																																	
Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
43	7-26-74			3																															
44	7-26-74																																		
45	7-26-74																																		
46	7-26-74																																		
47	7-27-74																																		
48	7-27-74																																		
49	7-27-74						1	2		9																									

Table A5. (cont'd).

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.
50	7-27-74											
51	7-27-74											
52	7-27-74											
53	7-27-74							38				
54	7-27-74											
55	7-28-74											
56	7-28-74								1	1		

Station	Date Collected	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata
50	7-27-74											
51	7-27-74											
52	7-27-74											
53	7-27-74											
54	7-27-74											
55	7-28-74											
56	7-28-74											6

Station	Date Collected	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
50	7-27-74		2										
51	7-27-74		12										
52	7-27-74		52										
53	7-27-74												
54	7-27-74												
55	7-28-74												
56	7-28-74		4									2	

Table A5. (cont'd).

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
57	7-28-74			2					1	3													1		1				3	1	6				
58	7-28-74																								1	1									
59	7-30-74																								22										
60	7-30-74																							1	4										
61	7-30-74						3		15																				58						
62	7-31-74																								15										
63	7-31-74																								22										

Table A5. (cont'd).

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
64	7-31-74						10			1											1				5										
65	7-31-74						3																												
66	8-2-74						12																												
67	8-2-74						11																		40										
68	8-2-74																																		
69	8-2-74						21																												
70	8-2-74						4																		12										

Table A5. (cont'd).

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
71	8-2-74							18						5																					
72	8-5-74																																		
73	8-5-74							4		1																									
74	8-5-74																								22										
75	8-5-74																								3										
76	8-5-74																																		
77	8-6-74						10																												

Table A5. (cont'd).

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
78	8-6-74			6				2		3				10					2				1		16		8		19					1	
79	8-6-74									13																									
80	8-6-74																																		
81	8-6-74			8	1																														
82	8-6-74						13																												
83	8-6-74			15	1																														
84	8-9-74																																		

Table A5. (cont'd).

Species	85	86	87	88	89	90	91
Date Collected	8-9-74	8-9-74	8-10-74	8-10-74	8-10-74	8-10-74	8-10-74
Campeloma decisum							
Viviparus georgianus							
Physa gyrina							
Physa ancillaria							
Physa integra							
Physa sp.				2			23
Helisoma trivolvis							
Helisoma campanulatum	4			4			
Helisoma anceps	14		10	22			
Helisoma truncatum							
Helisoma sp.							
Somatogyrus subglobosus							
Ferrissia parallela							
Ferrissia tarda							
Aplexa hyponorum							
Lymnaea obrussa							
Lymnaea columella							
Lymnaea megasoma							
Lymnaea exilis							
Lymnaea sp.							
Menetus exacuous							
Valvata tricarinata							
Valvata sincera	1						
Amnicola limosa						3	
Amnicola lustrica	1				15		
Amnicola integra							
Amnicola sp.							
Gyraulus parvus			15				
Gyraulus deflectus				6			
Gyraulus hirsutus	2						
Gyraulus umbilicatellus							
Gyraulus altissimus							
Gyraulus circumstriatus							
Gyraulus sp.							

Table A5. (cont'd).

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
92	8-11-74						13										9																		
93	8-11-74						12																												
94	8-11-74						4																												
95	8-12-74																																		
96	8-12-74																																		
97	8-12-74																																		
98	8-12-74																																		

Table A5. (cont'd).

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
99	8-12-74								3																										
100	8-12-74																																		
101	8-12-74																								26										
102	8-13-74	1		4																															
103	8-13-74						20			20																									
104	8-13-74							6		28																									
105	8-13-74																																		

Table A5. (cont'd).

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
106	8-14-74									3																									
107	8-14-74																																		
108	8-14-74						15																												
109	8-14-74																								25										
110	8-16-74																																		
111	8-16-74																																		
112	8-19-74																																		

Table A5. (cont'd).

Station	Date Collected	Species																																
		Campeloma decisum	*Viviparus georgianus*	*Physa gyrina*	*Physa ancillaria*	*Physa integra*	*Physa sp.*	*Helisoma trivolvis*	*Helisoma campanulatum*	*Helisoma anceps*	*Helisoma truncatum*	*Helisoma sp.*	*Somatogyrus subglobosus*	*Ferrissia parallela*	*Ferrissia tarda*	*Aplexa hyponorum*	*Lymnaea obrussa*	*Lymnaea columella*	*Lymnaea megasoma*	*Lymnaea exilis*	*Lymnaea sp.*	*Menetus exacuous*	*Valvata tricarinata*	*Valvata sincera*	*Amnicola limosa*	*Amnicola lustrica*	*Amnicola integra*	*Amnicola sp.*	*Gyraulus parvus*	*Gyraulus deflectus*	*Gyraulus hirsutus*	*Gyraulus umbilicatellus*	*Gyraulus altissimus*	*Gyraulus circumstriatus*	*Gyraulus sp.*
113	8-20-74			3					22	1				1											1									
114	8-20-74						34																											
115	8-20-74						8	2																										
116	8-21-74									18																								
117	8-21-74							12		13																								
118	8-21-74						12																											
119	8-21-74																																	

Table A5. (cont'd).

Station	120	121	122	123	124	125	126
Date Collected	8-21-74	8-22-74	8-22-74	8-22-74	8-22-74	8-23-74	8-23-74
Species							
Campeloma decisum							
Viviparus georgianus							
Physa gyrina							
Physa ancillaria	1						
Physa integra							
Physa sp.	9	11					
Helisoma trivolvis	6						
Helisoma campanulatum							
Helisoma anceps	9						
Helisoma truncatum							
Helisoma sp.							
Somatogyrus subglobosus							
Ferrissia parallela							
Ferrissia tarda							
Aplexa hyponorum							
Lymnaea obrussa							
Lymnaea columella							
Lymnaea megasoma							
Lymnaea exilis							
Lymnaea sp.							
Menetus exacuous							
Valvata tricarinata							
Valvata sincera							
Amnicola limosa						10	36
Amnicola lustrica							
Amnicola integra							
Amnicola sp.							
Gyraulus parvus							
Gyraulus deflectus							
Gyraulus hirsutus							
Gyraulus umbilicatellus							
Gyraulus altissimus	1						
Gyraulus circumstriatus							
Gyraulus sp.							

Table A5. (cont'd).

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
127	8-23-74						1			10																									
128	8-24-74									3																									
129	8-24-74																																		
130	8-24-74						26																												
131	8-24-74						17																												
132	8-24-74				11																														
133	8-24-74								1	2																									

Table A5. (cont'd).

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
134	8-24-74						11																												
135	8-24-74																																		
136	8-24-74																																		
137	8-20-74																																		
138	8-10-74																																		
139	6-6-74																																		
140	8-29-74																								52										

Table A5. (cont'd).

Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
141	8-29-74																								51										
142	8-29-74			25																				23											
143	9-7-74																								25										
144	9-9-74						17																												
145	10-5-74																																		
146	10-21-74																																		
147	10-21-74																																		

Table A5. (cont'd).

		Species																																
Station	Date Collected	Campeloma decisum	Viviparus georgianus	Physa gyrina	Physa ancillaria	Physa integra	Physa sp.	Helisoma trivolvis	Helisoma campanulatum	Helisoma anceps	Helisoma truncatum	Helisoma sp.	Somatogyrus subglobosus	Ferrissia parallela	Ferrissia tarda	Aplexa hyponorum	Lymnaea obrussa	Lymnaea columella	Lymnaea megasoma	Lymnaea exilis	Lymnaea sp.	Menetus exacuous	Valvata tricarinata	Valvata sincera	Amnicola limosa	Amnicola lustrica	Amnicola integra	Amnicola sp.	Gyraulus parvus	Gyraulus deflectus	Gyraulus hirsutus	Gyraulus umbilicatellus	Gyraulus altissimus	Gyraulus circumstriatus	Gyraulus sp.
148	10-21-74			7				1																											
149	10-21-74																																		

Table A6. The Occurrence of Twenty-Nine Species of Aquatic Snails Along Various Bottoms. (Number in parentheses indicates the total number of snails collected along a particular bottom).

Physa ancillaria	*Physa gyrina*	*Viviparus georgianus*	Species *Campeloma decisum*	Bottom	Number of Sites
0(0)	1(2)	0(0)	0(0)	Sand	(1)
0(0)	0(0)	0(0)	0(0)	Sand, Gravel	(3)
0(0)	3(32)	0(0)	1(1)	Sand, Gravel, Detritus	(8)
0(0)	0(0)	0(0)	0(0)	Sand, Bedrock	(1)
1(1)	2(2)	1(9)	3(14)	Sand, Rubble	(14)
0(0)	3(4)	0(0)	0(0)	Sand, Rubble, Detritus	(21)
0(0)	1(2)	0(0)	0(0)	Sand, Rubble, Boulders	(3)
0(0)	1(5)	0(0)	0(0)	Sand, Rubble, Boulders Detritus	(2)
0(0)	4(22)	0(0)	1(4)	Sand, Detritus	(19)
0(0)	1(3)	0(0)	0(0)	Fibrous peat, Muck Detritus	(2)
0(0)	0(0)	0(0)	0(0)	Pulpy peat, Muck	(1)
0(0)	3(3)	0(0)	0(0)	Pulpy peat, Muck, Detritus	(4)
2(2)	2(25)	0(0)	0(0)	Muck	(10)
0(0)	1(6)	0(0)	1(2)	Muck, Sand	(5)
0(0)	1(3)	0(0)	0(0)	Muck, Sand, Rubble, Detritus	(5)
0(0)	0(0)	0(0)	0(0)	Muck, Sand, Boulders Detritus	(1)
1(11)	7(17)	0(0)	0(0)	Muck, Sand, Detritus	(16)
0(0)	1(6)	0(0)	0(0)	Muck, Rubble, Detritus	(3)
2(4)	7(120)	0(0)	2(3)	Muck, Detritus	(30)

Table A6. (cont'd).

Helisoma anceps	Helisoma campanulatum	Helisoma trivolvis	Species Physa integra	Bottom	Number of Sites
1(3)	0(0)	0(0)	0(0)	Sand	(1)
1(1)	0(0)	0(0)	0(0)	Sand, Gravel	(3)
2(6)	1(1)	0(0)	0(0)	Sand, Gravel, Detritus	(8)
0(0)	0(0)	0(0)	0(0)	Sand, Bedrock	(1)
5(10)	0(0)	2(5)	0(0)	Sand, Rubble	(14)
5(8)	0(0)	1(1)	0(0)	Sand, Rubble, Detritus	(21)
1(2)	0(0)	0(0)	0(0)	Sand, Rubble, Boulders	(3)
0(0)	0(0)	0(0)	0(0)	Sand, Rubble, Boulders Detritus	(2)
4(17)	1(4)	3(43)	0(0)	Sand, Detritus	(19)
0(0)	0(0)	0(0)	0(0)	Fibrous peat, Muck, Detritus	(2)
1(1)	0(0)	0(0)	0(0)	Pulpy peat, Muck	(1)
1(1)	0(0)	2(20)	0(0)	Pulpy peat, Muck, Detritus	(4)
7(100)	0(0)	5(25)	0(0)	Muck	(10)
4(28)	0(0)	1(2)	0(0)	Muck, Sand	(5)
2(7)	0(0)	1(5)	1(1)	Muck, Sand, Rubble, Detritus	(5)
0(0)	0(0)	0(0)	0(0)	Muck, Sand, Boulders, Detritus	(1)
5(74)	3(38)	1(6)	0(0)	Muck, Sand, Detritus	(16)
0(0)	0(0)	1(2)	0(0)	Muck, Rubble, Detritus	(3)
16(120)	6(16)	5(11)	1(2)	Muck, Detritus	(30)

Table A6. (cont'd).

Species: *Ferrissia tarda*	*Ferrissia parallela*	*Somatogyrus subglobosus*	*Helisoma truncatum*	Bottom	Number of Sites
0(0)	0(0)	0(0)	0(0)	Sand	(1)
0(0)	0(0)	0(0)	1(1)	Sand, Gravel	(3)
0(0)	1(1)	0(0)	0(0)	Sand, Gravel, Detritus	(8)
0(0)	0(0)	0(0)	0(0)	Sand, Bedrock	(1)
1(1)	0(0)	1(2)	0(0)	Sand, Rubble	(14)
2(10)	2(2)	0(0)	0(0)	Sand, Rubble, Detritus	(21)
0(0)	1(1)	0(0)	0(0)	Sand, Rubble, Boulders	(3)
0(0)	0(0)	0(0)	0(0)	Sand, Rubble, Boulders, Detritus	(2)
0(0)	0(0)	0(0)	2(2)	Sand, Detritus	(19)
0(0)	0(0)	0(0)	0(0)	Fibrous peat, Muck, Detritus	(2)
0(0)	0(0)	0(0)	0(0)	Pulpy peat, Muck	(1)
0(0)	1(5)	0(0)	0(0)	Pulpy peat, Muck, Detritus	(4)
0(0)	0(0)	0(0)	0(0)	Muck	(10)
0(0)	1(10)	0(0)	0(0)	Muck, Sand	(5)
0(0)	1(2)	0(0)	0(0)	Muck, Sand, Rubble Detritus	(5)
0(0)	0(0)	0(0)	0(0)	Muck, Sand, Boulders, Detritus	(5)
0(0)	1(1)	0(0)	0(0)	Muck, Sand, Detritus	(16)
0(0)	0(0)	0(0)	0(0)	Muck, Rubble, Detritus	(3)
0(0)	0(0)	0(0)	0(0)	Muck, Detritus	(30)

Table A6. (cont'd).

Lymnaea megasoma	*Lymnaea columella*	*Lymnaea obrussa*	Species *Aplexa hyponorum*	Bottom	Number of Sites
0(0)	0(0)	0(0)	0(0)	Sand	(1)
0(0)	0(0)	0(0)	0(0)	Sand, Gravel	(3)
0(0)	0(0)	0(0)	0(0)	Sand, Gravel, Detritus	(8)
0(0)	0(0)	0(0)	0(0)	Sand, Bedrock	(1)
0(0)	0(0)	0(0)	0(0)	Sand, Rubble	(14)
0(0)	0(0)	2(10)	0(0)	Sand, Rubble, Detritus	(21)
0(0)	0(0)	0(0)	0(0)	Sand, Rubble, Boulders	(3)
0(0)	0(0)	0(0)	0(0)	Sand, Rubble, Boulders Detritus	(2)
0(0)	1(2)	1(2)	0(0)	Sand, Detritus	(19)
0(0)	0(0)	0(0)	0(0)	Fibrous peat, Muck, Detritus	(2)
0(0)	0(0)	0(0)	0(0)	Pulpy peat, Muck	(1)
0(0)	0(0)	0(0)	0(0)	Pulpy peat, Muck, Detritus	(4)
0(0)	0(0)	0(0)	0(0)	Muck	(10)
1(2)	0(0)	0(0)	0(0)	Muck, Sand	(5)
0(0)	0(0)	0(0)	0(0)	Muck, Sand, Rubble, Detritus	(5)
0(0)	0(0)	0(0)	0(0)	Muck, Sand, Boulders, Detritus	(1)
0(0)	1(3)	0(0)	0(0)	Muck, Sand, Detritus	(16)
0(0)	0(0)	0(0)	0(0)	Muck, Rubble, Detritus	(3)
0(0)	0(0)	0(0)	1(1)	Muck, Detritus	(30)

Table A6. (cont'd).

Valvata sincera	Valvata tricarinata	Promenetus exacuous	Species Lymnaea exilis	Bottom	Number of Sites
0(0)	0(0)	0(0)	0(0)	Sand	(1)
0(0)	0(0)	0(0)	0(0)	Sand, Gravel	(3)
0(0)	3(11)	1(1)	0(0)	Sand, Gravel, Detritus	(8)
0(0)	0(0)	0(0)	0(0)	Sand, Bedrock	(1)
0(0)	0(0)	1(1)	0(0)	Sand, Rubble	(14)
0(0)	1(1)	0(0)	0(0)	Sand, Rubble, Detritus	(21)
0(0)	0(0)	0(0)	0(0)	Sand, Rubble, Boulders	(3)
0(0)	0(0)	0(0)	0(0)	Sand, Rubble, Boulders, Detritus	(2)
0(0)	1(1)	0(0)	1(6)	Sand, Detritus	(19)
0(0)	0(0)	0(0)	0(0)	Fibrous peat, Muck, Detritus	(2)
0(0)	0(0)	0(0)	0(0)	Pulpy peat, Muck	(1)
0(0)	0(0)	0(0)	0(0)	Pulpy peat, Muck, Detritus	(4)
0(0)	0(0)	0(0)	0(0)	Muck	(10)
0(0)	1(1)	0(0)	0(0)	Muck, Sand	(5)
0(0)	1(34)	0(0)	0(0)	Muck, Sand, Rubble Detritus	(5)
0(0)	0(0)	0(0)	0(0)	Muck, Sand, Boulders, Detritus	(1)
0(0)	1(5)	1(3)	0(0)	Muck, Sand, Detritus	(16)
0(0)	0(0)	0(0)	0(0)	Muck, Rubble, Detritus	(3)
4(26)	3(10)	0(0)	1(5)	Muck, Detritus	(30)

Table A.6. (cont'd).

Gyraulus parvus	Amnicola integra	Amnicola lustrica	Species Amnicola limosa	Bottom	Number of Sites
0(0)	0(0)	0(0)	0(0)	Sand	(1)
1(4)	0(0)	1(1)	1(1)	Sand, Gravel	(3)
4(11)	0(0)	0(0)	5(49)	Sand, Gravel, Detritus	(8)
0(0)	0(0)	0(0)	0(0)	Sand, Bedrock	(1)
0(0)	1(2)	1(1)	5(69)	Sand, Rubble	(14)
5(11)	1(1)	0(0)	9(107)	Sand, Rubble, Detritus	(21)
0(0)	0(0)	0(0)	1(1)	Sand, Rubble, Boulders	(3)
0(0)	0(0)	0(0)	0(0)	Sand, Rubble, Boulders, Detritus	(2)
5(22)	0(0)	1(2)	5(111)	Sand, Detritus	(19)
0(0)	0(0)	0(0)	0(0)	Fibrous peat, Muck, Detritus	(2)
1(1)	0(0)	0(0)	0(0)	Pulpy peat, Muck	(1)
0(0)	0(0)	0(0)	1(2)	Pulpy peat, Muck, Detritus	(4)
0(0)	0(0)	0(0)	2(12)	Muck	(10)
2(34)	1(8)	0(0)	3(74)	Muck, Sand	(5)
2(2)	0(0)	0(0)	3(16)	Muck, Sand, Rubble Detritus	(5)
0(0)	0(0)	0(0)	0(0)	Muck, Sand, Boulders, Detritus	(1)
2(62)	0(0)	1(15)	5(125)	Muck, Sand, Detritus	(16)
1(1)	0(0)	0(0)	1(5)	Muck, Rubble, Detritus	(3)
5(24)	0(0)	1(1)	8(84)	Muck, Detritus	(30)

Table A6. (cont'd).

Gyraulus altissimus	*Gyraulus umbilicatellus*	*Gyraulus hirsutus*	Species *Gyraulus deflectus*	Bottom	Number of Sites
0(0)	0(0)	0(0)	0(0)	Sand	(1)
0(0)	0(0)	0(0)	0(0)	Sand, Gravel	(3)
0(0)	0(0)	2(11)	2(5)	Sand, Gravel, Detritus	(8)
0(0)	0(0)	0(0)	0(0)	Sand, Bedrock	(1)
0(0)	1(1)	0(0)	1(2)	Sand, Rubble	(14)
0(0)	0(0)	0(0)	0(0)	Sand, Rubble, Detritus	(21)
0(0)	0(0)	0(0)	0(0)	Sand, Rubble, Boulders	(3)
0(0)	0(0)	0(0)	0(0)	Sand, Rubble, Boulders, Detritus	(2)
0(0)	0(0)	3(9)	1(16)	Sand, Detritus	(19)
0(0)	0(0)	0(0)	0(0)	Fibrous peat, Muck, Detritus	(2)
0(0)	0(0)	0(0)	0(0)	Pulpy peat, Muck	(1)
0(0)	0(0)	0(0)	0(0)	Pulpy peat, Muck, Detritus	(4)
1(1)	0(0)	0(0)	1(5)	Muck	(10)
0(0)	0(0)	0(0)	0(0)	Muck, Sand	(5)
0(0)	0(0)	0(0)	0(0)	Muck, Sand, Rubble, Detritus	(5)
0(0)	0(0)	0(0)	0(0)	Muck, Sand, Boulders, Detritus	(1)
0(0)	0(0)	1(1)	1(3)	Muck, Sand, Detritus	(16)
0(0)	0(0)	1(2)	0(0)	Muck, Rubble, Detritus	(3)
1(2)	0(0)	4(10)	4(38)	Muck, Detritus	(30)

Table A6. (cont'd).

Species: Gyraulus circumstriatus	Bottom	Number of Sites
0(0)	Sand	(1)
0(0)	Sand, Gravel	(3)
1(10)	Sand, Gravel, Detritus	(8)
0(0)	Sand, Bedrock	(1)
0(0)	Sand, Rubble	(14)
0(0)	Sand, Rubble, Detritus	(21)
0(0)	Sand, Rubble, Boulders	(3)
0(0)	Sand, Rubble, Boulders, Detritus	(2)
0(0)	Sand, Detritus	(19)
0(0)	Fibrous peat, Muck, Detritus	(2)
0(0)	Pulpy peat, Muck	(1)
0(0)	Pulpy peat, Muck, Detritus	(4)
0(0)	Muck	(10)
2(3)	Muck, Sand	(5)
0(0)	Muck, Sand, Rubble, Detritus	(5)
0(0)	Muck, Sand, Boulders, Detritus	(1)
0(0)	Muck, Sand, Detritus	(16)
0(0)	Muck, Rubble, Detritus	(3)
0(0)	Muck, Detritus	(30)